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BIOGRAPHICAL NOTICE OF WILLIAM HENRY PETTEE.

By ISRAEL C. RUSSELL, Ann Arbor, Mich.

PORTRAIT, PLATE I.

William Henry Pettee was born in Newton Upper Falls, Mass., January 13, 1836, of representative New England parentage. His father was a manufacturer of cotton fabrics and of mill machinery. In boyhood his studious tastes had to be restrained and his college preparation delayed out of regard to his somewhat slender bodily frame. He entered Harvard College at nineteen years of age, took high rank in the required classical course of that period, was selected to deliver a Latin oration in his junior year, and graduated with distinction in the class of 1861. He continued in graduate work in the same university for over three years, receiving the degree of master of arts in 1864, studying at first in the engineeing department of the Lawrence Scientific School and later in the college, where at the same time he was an assistant.

From 1865 to 1869 he traveled and studied in Europe, his main work being in the Royal Mining Academy of Saxony, at Freiberg, with vacations in the mining regions of Germany.

In 1868 Mr. Pettee returned to Harvard University as a teacher in the School of Mining and Practical Geology then established under the direction of Josiah D. Whitney. His appointment in 1869, was that of instructor in mining, but in 1871 he was advanced to the rank of assistant professor in the same branch, and provision made for work upon geo-

logical surveys to be carried on under the auspices of the Harvard School of Mining.

In the summer of 1869, professor Pettee made a geological and topographical survey of South Park, Colorado, and during the year 1870-71, having been granted a leave of absence from Harvard, he became connected with the California State Geological Survey. Besides making a study of gold-bearing gravels of California, he undertook systematic work in correction of the determination of altitudes by means of the barometer. Some of the results of this investigation, collected from the detailed reports of the survey, were published by authority of the California State Legislature in 1874, entitled Contributions to Barometric Hypsometry, with Tables for use in California, to which a supplement was added in 1878. Prof. Whitney's estimate of the onerous labor, the accuracy and perseverance of Prof. Pettee's work in this undertaking appears in the prefatory note to the volume above mentioned.

From 1871 to 1875 in addition to other duties Prof. Pettee gave instruction to an elective section of undergraduates in physical geography, geology, and meteorology at Harvard, but before 1875 the conditions of the gift supporting a school of mining at that institution were altered and provisions for a special instructor in these subjects was with drawn.

In 1875 professor Pettee was appointed to a professorship of mining engineering and related subjects in the University of Michigan, a position which he held with various changes of title, until his death.

In the first semester of 1879-80, Prof. Pettee was granted leave of absence from the University of Michigan to continue his investigations of the auriferous gravels of California. His report on that work was published as an appendix to the first volume of Whitney's "Contributions to American Geology." It has been adjudged to show that careful examination of phenomena, weighing of evidence, and painstaking accuracy, which those best acquainted with professor Pettee always expect in papers prepared by his hand.

The annual transactions of the American Institute of Mining Engineers have been submitted to professor Pettee for many years, for critical proof-reading and correction. Of

that society he was a life-member, his election dating from 1871. For many years he was a co-worker with its secretary, Rossiter W. Raymond, who in a recent memorial published in the Transactions of the Institute, expressed high appreciation of professor Pettee's ability as a literary critic. He was one of the original fellows of the Geological Society of America; a fellow of the American Association for the Advancement of Science, in which he was general secretary in 1887; a member of the American Academy of Arts and Sciences during his residence in Massachusetts; and a member of the American Philosophical Society of Philadelphia.

For professor Pettee, the members of the Faculty of the University of Michigan, of which he was a member for twenty-nine years, hold only memories of the highest respect and the warmest friendship. These cherished sentiments are but a reflection of his own genial and loving nature, left by him as an inheritance to all with whom he came in contact. His more pronounced characteristics as revealed in his intercourse with his colleagues whether personally and socially or in connection with official duties, and equally conspicuous to the students who received his instruction, were a kindly and loving nature, patience under difficulties, painstaking accuracy in all of his work, love of truth, and unswerving uprightness of character. With these high ideals were coupled an abundant and ever accessible knowledge of the history and traditions of education in Michigan, and a love for the branches of science to which he devoted his time and energy.

Professor Pettee died at his home in Ann Arbor, Michigan, on May 26, 1904. While his chief work during life was that of a teacher, his few contributions to geology and kindred subjects show that he was a painstaking and accurate observer.

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"Report of an examination of portions of the gravel mining

regions of California; in Placer, Nevada, Yuba, Sierra, Plumas, and Butte counties; made in 1879." Appendix A, pp. 379-487, of "The auriferous gravels of the Sierra Nevada of California," Vol. 1, "Contributions to American geology," by J. D. Whitney, Harvard College, Museum of Comparative Zoology, Memoirs, Vol. 6, Cambridge, 1880.

PRESENT PROBLEMS OF GEOPHYSICS.*

By George F. Becker, Washington, D. C.

Advances in science are seldom made without a view to the solution of specific, concrete problems, even when the results of investigation possess the widest generality. The history of science is full of instances of the fruitfulness of researches the immediate purposes of which were narrowly defined. Geophysics is only that portion of general physics, including under that term physical chemistry, which is applicable to the elucidation of the past history and present condition of the earth. It is thus a very definite branch of applied science, the exigencies of which call for the solution of a group of related problems. These, however, possess great interest apart from their application to the globe, while for the most part they offer very serious experimental and theoretical difficulties. Had they been easy, they might have been solved long ago, for many of these problems have been propounded and more or less discussed from the birth of modern science to the present day. Their difficulty, not lack of recognition of their importance, has postponed their solution.

The main purpose of this paper is to deal with the order in which it would be expedient to investigate the questions embraced under the head of geophysics, but a brief and incomplete enumeration of the problems from a geological standpoint will serve to lend a coherency and a human interest to the subject which it would otherwise lack.

Physical geology begins with the solar nebula and the genesis of the earth-moon system. The harmonies of the

*Address delivered at the International Congress of Arts and Science, at St. Louis, before the Geophysical Section of Department 12, on September 21, 1904.

solar system compelled the immortal Kant and the ever-living Laplace to seek the origin of the planets, the sun and the other stars in heterogeneous nebulas which they supposed to have condensed about one or several nuclei. Every attempt to devise an essentially different hypothesis has failed, and every history of the globe which begins after the birth of the planet is unsatisfying. In the drama of the universe there must have been pre-nebular scenes, but of these we have as yet no inkling. The nebular hypothesis, as its authors propounded it, explains the similarity in the composition of the members of the solar system which is indicated by the analysis of meteorites and by the spectroscope, though the facts thus revealed were unknown to Kant and Laplace. It is also compatible with and accounts for the heterogeneity in the composition of the earth manifested in the actual asymmetric distribution of oceans, mountain ranges and anomalies of gravitational force, as well as in the curiously local occurrence of certain ores (such as those of tin and mercury) and in the predominance of certain alkalies among the rocks over wide areas.

This heterogeneity, however, is of a small order of magnitude. The general dependence of gravity on latitude, the nearly spheroidal shape of the earth and other phenomena show that the distribution of density is nearly symmetrical, while the divergence of the spheroid from the figure characteristic of a fluid of the same mean density and mass as the earth demonstrates that the interior layers of equal density are oblate. These and similar facts are consistent with and are strong evidence for the hypothesis that the globe has been fused at least to a considerable depth from the glowing surface of the gathering nebulous mass. Nevertheless, Houghton, and more recently professor Chamberlin, have supposed that the accretion of nebulous matter was so slow that the heat of impact did not suffice to produce fusion. The hypothesis of superficial fusion is not incompatible with the minor heterogeneity pointed out above; for the laws of diffusion in viscous fluids give proof that sensibly perfect homogeneity could not be produced even in 50,000,000 years throughout a body of liquid originally heterogeneous and possessing a tenth of the mass of the earth. On

the other hand, there is no known ground other than mere convenience for supposing an original homogeneity either of the nebula or of the earth.

The problem of the distribution of density in the earth is one of the most important in all geophysics. It is as significant for geodesy and terrestrial magnetism as for geology. That Laplace's empirical law represents it approximately is generally acknowledged, but it appears substantially certain that this is merely an approximation without theoretical value. Only extended researches, however, can replace it by one better founded.

The solidity of the earth is now very generally accepted, though Descartes's hypothesis of its fluidity, invented to satisfy his erroneous theory of vortices, died hard. Lord Kelvin showed from tidal phenomena that the effective rigidity of the earth is about that of a continuous globe of steel. Professor Newcomb pointed out that the Chandlerian nutation leads to the same conclusion and an almost identical value of the modulus of rigidity, and professor George H. Darwin demonstrated that, if the earth is a viscous fluid, its viscosity must be some 20,000 times as great as that of hard brittle pitch near the freezing point of water. From the point of view of modern physical chemistry and in consideration of professor Arrhenius's opinions, the matter requires further consideration. In particular it is most important to know whether the earth is substantially a crystalline solid or an amorphous substance, for many modern physical chemists consider amorphous matter as liquid. This opinion is far from being established, however, and recent experiments by Mr. Spring show that mere deformation at ordinary temperatures attended by only a very small absorption of energy, suffices to convert crystalline metals into substances exhibiting characteristics of amorphous bodies. Since Nordenskiöld's great discovery of great masses of terrestrial iron, or, rather, nickel steel, in Greenland, and the wide distribution since proved for similar metal imbedded in igneous rocks, a great amount of evidence has accumulated that a large part of the earth is composed of material indistinguishable from that of metallic meteorites. Meteoric iron is of course a highly crystalline material.

It is a very striking fact that the mean rigidity of the earth is about that of steel, for the only substances likely to occur in extensive continuous masses and displaying such rigidity at ordinary temperatures and pressures is steel itself. Nevertheless, the conclusion can not yet be drawn from the resistance to deformation displayed by the earth, that it is chiefly composed of steel. Elastic resistance is known to be a function both of pressure and of temperature, and until this function has been determined by theory and experiment, the bearing of the evaluation of rigidity by tidal action can not be ascertained.

Having shown the earth to be a solid globe, lord Kelvin calculated its age from one of Fourier's theorems, assuming for purposes of computation an initial temperature of 7000 degrees F. (nearly 3900 degrees C.) and that the thermal diffusivity of the earth is that of average rock. These assumptions, with the observation that the temperature near the surface of the earth increases at the rate of 1 degree F. for every 50 feet of depth, lead to an age of 98,000,000 years; but on account of the uncertainty as to conductivities and specific heats in the interior, the conclusion drawn by lord Kelvin was only that the time elapsed since the inception of cooling is between 20 and 400 million years.

Clarence King subsequently took a further important step on the basis of data determined at his request by professor Carl Barus on the volume changes which take place in diabase during congelation, and on the effects of pressure in modifying the melting and solidifying points. Assuming that the earth can never have had a crust floating on a liquid layer of inferior density, computation leads him to 24 million years as the maximum period for the time since superficial consolidation was effected, provided that the superficial temperature gradient and conductivity are correctly determined.

These researches, together with Helmholtz's investigation on the age of the solar system, which is incomplete for lack of knowledge of the distribution of density in the sun, have had a restraining influence on the estimates drawn from sedimentation by geologists. Many and perhaps most geologists now regard something less than 100 million years

as sufficient for the development of geological phenomena. Yet the subject can not be regarded as settled until our knowledge of conductivities is more complete. An iron nucleus, for example, would imply greater conductivity of the interior and a higher age for the earth than that computed by King, though probably well within the range explicitly allowed by lord Kelvin in view of the uncertainty of this datum.

The researches of Kelvin and Darwin, supplementing those of Kant and others, have left no doubt that the moon was formerly closer to the earth than it now is, and that the rotation of the latter was more rapid, involving a greater ellipticity of the meridan than it now shows. In a fluid or Cartesian earth the change of figure might have produced little effect on the structure of the planet. If the earth is chiefly a mass of crystalline nickel steel, it is very possible that such a change in the figure of equilibrium might rupture it. Since the epoch at which the earth rotated in 5 hours 30 monutes the polar axis must have elongated by several per cent., most of it before the time of rotation was reduced to 11 hours.* Were the earth chiefly composed of forged steel, such elongation might be produced by plastic deformation; but meteoric iron is rather comparable with cast iron, or better still, with relatively brittle, unforged cement steel, and might break.

Now it is an indubitable fact that a majority of the outlines of the great oceanic basins and the chief tectonic lines of the globe, lie nearly on great circles tangent to the Arctic ocean and to the Antarctic continent.† These lines, or most of them, are of extremely high geological age, their main features having found expression as early as the oldest known fossils and in some cases still earlier. It appears to

*Compare Thompson and Tait, 'Nat. Phil.,' Sec. 772, where the rotational period and eccentricity are given for a fluid of the mass of the earth and possessing its mean density. When the period is 5h. 30m., this table gives the data for computing that the polar axis has a length equal to 0.95 of the length which it has when the period is a sidereal day. For rotation in 10h. 57m. the polar axis is 0.99 times that for a day.

† In 1857 professor R. Owen, of Tennessee, and independently, Benjamin Pierce, called attention to the tangency of the coast lines to the polar circles (not to the coast lines of the arctic sea and the antarctic continent), each attributing the facts to the influence of the sun. In the first 'Yearbook' of the Carnegie Institution I failed to refer to these publications.

me very possible that these fundamental ruptures of the globe were due to the change of figure attendant upon the diminution of the earth's period of rotation. Their symmetrical disposition with reference to the polar axis is unquestionable, as well as the fact that they penetrate to great depths. They must be due to some tremendous force acting axially, which actually altered the ellipticity of the meridian, since these fissures could not have been formed without modifying the shape of the globe, and the only known disturbance of this description is the change of figure referred to. On the other hand, were the earth homogeneous, such ruptures would be expected to have as envelopes small circles in latitude 45 degrees instead of at about latitude 70 degrees. But since the earth is not homogeneous, this discordance does not invalidate the suggestion.

Be this as it may, upheavals, subsidences and attendant contractions have been in progress throughout the whole of historical geology or the period within which fossils afford a guide to the succession of strata. The so-called contractional theory has shown itself wholly inadequate to account for the amount of deformation traceable in the rocks of the globe, nor has the extravasation of igneous rock been sufficient to account for the phenomena. To me the earth appears to be a somewhat imperfect heat engine in which the escape of thermal energy is attended by the conversion of a part of the supply into the vast amount of molar energy manifested in the upthrust and crumpling of the continents. The subject will probably turn out to be accessible mathematically after certain experimental determinations have been made and I shall return to it presently.

Orogeny or mountain building is a mere detail of the more general subject of upheaval and subsidence, but it exhibits problems of great complexity both from the experimental and from the theoretical points of view. There is no question that unit strains are often reached or even surpassed in contorted strata and in belts of slate, but the theories of elasticity and plasticity as yet developed are inadequate to deal with these strains in complex cases. An investigation on finite elastic and plastic strain is now under way in my laboratory and has made gratifying progress thus

far; but this is not the place for detailed results. Something also has been done in the way of working out homogeneous finite strains in rocks, so that the general nature of joints, faults and systems of fissures and the mechanism of faulting is now fairly clear. The theory of slaty cleavage is a subject of dispute in which I have taken part. Few colleagues appear to agree with me that this cleavage is due to weakening of cohesion on planes of maximum slide, but I am not hopeless that my view will make its way to favor in time.

Seismology is a vast subject by itself, but one almost totally lacking in theoretical foundation. Seismological observations should afford the means of exploring the elastic properties of the earth throughout its interior, but the theory of the vibrations of a spheroid like the earth is not yet worked out. Meantime observations are being accumulated, but it can be foreseen that these will contribute little to elucidation until they include the vertical components of the vibrations as well as the horizontal ones. In other words, we must know the angle at which the wave emerges from the surface as well as its azimuth. The causes and conditions of earthquakes afford a separate topic of great interest. That some of them are of volcanic origin is evident; others appear to be due to paroxysmal faulting, yet there is very possibly a common underlying cause.

On no subject are opinions more divergent than concerning the origin and mechanism of volcanoes. To the ancients they were the mouths of the river Phlegethon. To those who adhere to the Cartesian doctrine they are communications with the liquid interior of the earth. Most geologists think of them as connected with hypogeal reservoirs of melted matter subsisting for indefinitely long periods of time. Finally it is conceivable that the lava may be extruded as soon as the melted mass has accumulated in sufficient quantity, somewhat as water may break through an obstructing dam after its depth reaches a certain value. The continual movements of the rocks show that they must be to some extent in a state of elastic strain, so that a given cubic mile of rock resists surrounding pressure in virtue both of its rigidity and of its compressibility. If that cubic

mile becomes liquid, its rigidity is gone and the change of shape of surrounding masses may aid in its expulsion. Of course imprisoned gases, especially the "juvenile waters" of professor Suess, may also play a very important part in expulsion. But the more I have studied the matter, the less probable it seems to me that considerable bodies of melted lava can remain quiet for long periods of time in the depths of the earth. The influences tending to their expulsion would seem to be at a maximum immediately after the fusion of enough material to supply an eruption.

Relief of pressure is often invoked to explain fusion of lava, but it is not a wholly satisfactory cause. If a deep crack were to form, the rock at the bottom might melt indeed, but, as the crack filled, the pressure and the solidity of the source would be restored. To me, Mallet's hypothesis is more satisfactory, so far as the explanation of fusion is concerned. Only those who have studied the minute evidence of mechanical action, in mountain ranges can appreciate the evidence they present of stupendous dissipation of energy. This has not indeed been enough to fuse rocks, but it is hard to conceive that it is always insufficient to furnish the latent heat of fusion to rocks already close to their melting point under the prevailing pressure. From this point of view, vulcanism is a feature of orogenic movement and it is to be looked for where relative motions are concentrated in zones so narrow that the local dissipation of energy is relatively intense. It is also possible that percolating waters, by reducing the melting points of rocks, sometimes bring about fusion without change of temperature. Such a hypothesis might fit the volcanoes of the Hawaiian islands where there is no known faulting in progress.

The physics of magmatic solution is a great subject which is experimentally almost untouched, although a vast amount of geological speculation has been based upon assumed properties of magmas. It is only within a few months that even satisfactory melting-point determinations of those most important rock-forming minerals, the lime-soda feldspars, have been made. The feldspars are only one series of isomorphous mineral mixtures. Their study is fundamental and must be followed by that of the remaining

class, i. e., the eutectics. These, in my opinion, will lead to a rational classification of igneous rocks, themselves mixtures and incapable of logical description except in terms of standard mixtures, the eutectics.

It appears to me highly probable, for many reasons, that the magmas of the granular rocks are not liquids but stiff emulsions, comparable with modeling clay, the solid constituents (perhaps free oxides) being merely moistened with magmatic liquids. Such masses behave mechanically like soft solids; they display some rigidity and in them diffusion is reduced to a vanishing quantity. They may be ruptured and the (aplitic or pegmatitic) liquid portion may then seep into the cracks. Such magma might be forced into minute fissures, as is the case when clay is molded to terra cotta articles and yet it would support permanently, on its upper surface, rocks of superior density. Only in such a magma can I comprehend the simultaneous growth of crystals of various minerals; for in a liquid not exactly eutectic, the formation of crystals must follow a definite order. Again, if banded gneisses and gabbros had been fluid, the bands would show evidences of diffusion which as a rule are absent or barely traceable in these rocks.

The relations between consanguineous massive rocks have occupied a large part of the attention of geologists for many years. At one time it was supposed that homogeneous liquid magmas might split up into two or more homogeneous magmas by processes of molecular flow due to differences of osmotic pressure. This process was called the differentiation of magmas. It has been shown, however, that these processes are so much slower even than heat diffusion, that they cannot be efficient beyond distances of a few centimeters. For this reason, Mr. Teall,* who first suggested the application of the Soret process to account for differentiation, professor Brögger† and others, have abandoned the hypothesis of differentiation on a considerable scale by molecular flow. Nevertheless, observations on laccoliths and other occurrences leave no doubt that a single magma may solidify to different though consanguineous

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* *Proc. Geol. Soc. London*, vol. 57, 1901, p.lxxxv.
†Eruptivgesteine der Kristianiagebietes, part III, p 339.

rocks. If the separation is not molecular it is self-evident that it must be molar. The only molar currents readily conceivable in a body of magma are convection currents, and these, or even an equivalent mechanical stirring, would necessarily lead to fractional crystallization, a familiar process known even to the pupils of Aristotle, and which is almost unavoidable when mixed solutions solidify. This process is one of precipitation and is absolutely distinct from the differentiation (or, more properly, segregation) of rock magmas, in which a single liquid is supposed to separate into two or more distinct liquids. The general conditions of the order of precipitation during fractional crystallization in acordance with the phase rule are by no means beyond the reach of discussion, and the able investigations of Messrs. J. H. L. Vogt and J. Morozewicz have a direct bearing on this subject.

A mystery which will assume greater importance as the accessible supply of coal diminishes is the origin of petroleum. There is much to be said in favor of the unpopular hypothesis of Mendeleef, supported by experiments on cast iron, that liquid hydrocarbons are due to the decomposition of the iron carbides of the terrestrial nucleus. Such vast accumulations of oil as exist on the Caspian and the Caucasus seem incompatible with the hypothesis of animal or vegetable origin, although oils belonging to the same series as do the petroleums have been produced in the laboratory from organic materials. On the other hand, some meteorites contain hydrocarbons (which may themselves be due to the alteration of iron carbides) and there are geologists who infer that the petroleum may be derived from the mass of the earth itself.* If the origin of the oil is not animal or vegetable, the supply is very likely inexhaustible. More extended study of the connection between volcanic phenomena and the origin of asphaltic and other hydrocarbons is a desideratum.

Ore deposits themselves form the branch of geology which was earliest cultivated and which will never lose its interest so long as mankind remains gainful. Yet much remains to be done by experiment for the theory and practice

*H. L. Fairchild, *Bull Geol. Soc. Amer.* vol. xv, 1904, p. 253.

of mining geology. The mechanism of the secondary enrichment of ores, particularly those of copper, detected by Mr. S. F. Emmons and enlarged upon by Mr. W. H. Weed, is being studied experimentally in the laboratories of the U. S. Geological Survey. A feature deserving careful experimental study is the osmotic separation of ores from their solutions by the wall rock. Many minutiae of occurrence suggested that the walls of veins often act as a species of diaphragm or molecular filter and have a dialytic action on the ore solutions.* The origin of the ores themselves is still very obscure and will hardly be elucidated until more is known of the earth's interior. Sometimes they seem to be derived from adjacent rocks; in other cases conditions suggest that the rocks and the veins derive their metallic content from a common deep-seated source. Here, as in several other connections, professor Suess's theory of "juvenile waters" is very suggestive. It is held that many of the great iron deposits are due to magmatic separation. Depositions of lead ores by replacement of calcite is a known process, but takes place under unknown conditions. In some cases replacement of rock by ores appears to me to be alleged without sufficient proof. Pseudomorphosis is the only adequate test of replacement.

Erosion appears to be a subject which is capable of more exact treatment than it has received. Weathering and abrasion proceed with a rapidity which increases with the surface exposed per unit of volume.* Hence these processes lead to minimum surfaces. Therefore also the mathematics of erosion is essentially identical with that of capillarity.

Geological climates are as interesting to astrophysicists as to meteorologists and geophysicists. Messrs. Langley and Abbot appear to have evidences of recent variations in solar emanation. If these have been considerable in the course of the period of historical geology, light should be thrown upon them by the paleontology of the tropics. Variations in the composition of the atmosphere must have been very influential in determining both the mean temperature of the earth's surface and the distribution of temperature; but so also is the distribution of water. No theory of the glacial

* "Min. Resources of the U. S. for 1892," p. 156.
* *U. S. Geol. Survey, Mon. XIII.* 1888, p. 68.

period seems generally accepted. Croll's theory is discredited. I have shown to my satisfaction that the astronomical conditions most favorable to glaciation are high obliquity and low eccentricity of the earth's orbit,† but can not claim any extensive following. If I am right, it should be possible to obtain a definite measure of geological time in years as soon as the astronomers have completed the theory of secular variations in the planetary system so far as to be able to assign the lapse of time between successive recurrences of low eccentricity and high obliquity.

A most interesting observation, which promises much light on the past history of the globe, is that lavas and strata indurated by lavas retain the polarity characteristic of the locality in which they cooled.‡ The time may come when this will lead to determinations of the relative age of lavas, the duration of periods of eruption and possibly even absolute determinations of date.

Geology has long, and with some justice, labored under the reproach of inexactitude. As has been illustrated in the preceding pages, the science is still in the qualitative stage and almost wholly lacks the precision of astronomy. Even its most ardent students have seldom succeeded in ascertaining the quantitative relations between effects and operative causes and have been perforce content to indicate tendencies. Thus geological doctrine is far too much a matter of opinion, but this is hardly the fault of the areal geologist. The country must be mapped both for economic reasons and to accumulate a knowledge of the facts to be explained. Working hypotheses the field geologist must have, or he could not prepare his map; and he is only responsible for living up to the standard of knowledge of his time. He is continually face to face with phenomena for which physics and chemistry should account, though they may have not yet done so, and must accept seeming probabilities were certainty is unattainable. So, too, Kepler's predecessors recorded facts and guessed at generalizations as best they might.

The physics of extreme conditions still awaits satisfactory exploration. The geologist turns to the physicist for

† *Amer. Jour. Sci.*, vol. xliii, 1894, p. 95.
‡ Brunhes and David. *Comptes Rendus*, vol. cxxxiii, 1901, p. 153.

help and in most cases meets with the reply: We can not tell. Astrophysics is in much the same situation. Astronomers know as little of the distribution of density in the stars or planets as do geologists. Real knowledge of the physics and chemistry of high temperatures would be as welcome to them as to us. After all, physical geology is the astrophysics of this, the only accessible planet. Geodesy, too, and terrestrial magnetism are waiting for the solution of geophysical problems. How much might be done, lord Kelvin and Mr. George H. Darwin have shown; but there are many problems too broad and too laborious to be solved by individual effort, and these are as essential to the rounding out of the science of physics as they are to the development of geology and astrophysics.

In the brief review which precedes, I have endeavored to show that the history of the earth bristles with problems, few of them completely solved, though in many cases we have some inkling of the solution. This sketch has been drawn for the purpose of considering the strategy of a campaign against the series of well intrenched positions occupied by our great enemy, the unknown.

Generalizing the results of the sketch presented, it is easy to see that nearly all the problems suggested involve investigation of the properties of solids, or of liquids, or of the transition from one phase to the other. It is the business of the experimental physicist to establish linear relations; it is the occupation of the mathematical physicist to draw logical inferences from these relations. Each will have plenty to do in a methodical study of geophysics.

There can be no doubt that the character of the earth's interior and the physical laws which there prevail constitute the most fundamental object of geological and geophysical research, while the results of successful investigation would be immediately applicable at least to the moon and Mars. No one questions that enormous pressures and very high temperatures exist near the earth's center, while the quality of matter which constitutes the interior can not be satisfactorily determined until we know how substances would behave under extreme pressure and at temperatures approaching 2,000 degrees C. There is every reason to suppose that

in geodesy and terrestrial magnetism, and cast backward through the vista of time a ray of light on the nebular hypothesis.

Again, when the law of elasticity and the approximate constitution of the globe are known, it will be possible to work out a satisfactory theory of the simpler modes of vibration in a terrestrial sphere, and then seismological observations can be applied to determining more precisely the intrinsic elastic moduluses of the earth along the paths of earthquake waves.

It will also be practicable to examine critically the possible rupture of the globe as a consequence of change of figure and to study intelligently the simpler cases of the crumpling of strata, fissuring and other problems in the mechanics of orogeny.

The science of elasticity has had a very disappointing history. Simple as is the assumption *ut tensio, sic vis*, the attempt to solve even such seemingly elementary problems as the flexure of a uniformly loaded rectangular bar leads to insoluble equations; so that the science has been relatively unfruitful. It remains to be seen whether a truer relation between load and strain will not simplify formulas and increase the applicability of algebra to concrete cases.

From an astrophysical point of view the dialytic action of mineral septa is unimportant, but it has a very interesting bearing on metamorphism and ore deposition, and may readily contribute to economic technology.

The relations of viscosity to the diffusion of matter have not yet been elucidated even for ordinary temperatures. This subject is one of much importance in connection with the genesis of rock species, and of course it should be studied at 10 degrees before undertaking researches at 1,000 degrees.

High temperature work is essential even in the investigation of the elastic problem and it is almost a virgin field. Even thermometry is very imperfect above the melting point of gold, though it is destined soon to become exact at least as high as 2,000 degrees, a range which will probably suffice for geophysics. But we are also in almost total ignorance of the extent to which the laws of physics, studied at ordinary temperatures, prevail at one or two thousand degrees. One

of the less difficult problems of this group is that of thermal conductivity and specific heat of solid bodies at high temperatures. For the principal metals this is already known as far as 100 degrees, but not for rocks or minerals. It would be especially desirable to have such determinations for granite, basalt and andesyte, the last representing the average composition of the accessible part of the lithosphere.

It seems to me that when the thermal diffusivities are known for these rocks, over a range of a thousand degrees, the question of upheaval and subsidence can be attacked with a good prospect of success. A cooling sphere is conceivable in which the distribution of thermal diffusivity is such that the flow of heat would be "steady," in Fourier's sense, and thus accompanied by no superficial deformation. With any other distribution of diffusivities, deformation would occur, and the globe would act as an imperfect heat engine, the work done being that of upheaval or subsidence. Now when the assuredly variable value of diffusivity for the materials of the globe is known, the mathematical conditions for steady flow can be worked out, and if these are not consistent with the facts of the globe, a vera causa for upheaval will have been found, which may lead to further and more detailed conclusions. It should also either elucidate or simplify the subject of fusion of magmas and their eruptive expulsion.

The data for constitution and thermal diffusivity will readily be applicable to the problem of the earth's age and will yield a corrected value of the probable lapse of time since the initiation of the *consistentior status* of the Protogaea.

The most difficult field in geophysics is the study of solutions at high temperatures. This is largely because both methods and apparatus require to be invented. When work of this kind was undertaken in the laboratory of the Geological Survey, three years since, no furnace existed in which pure anorthite could be melted and a trustworthy determination of the temperature of fusion made. For the study of aqueo-igneous fusion which must, of course, be formed at considerable pressures, extremely elaborate preparation is necessary; indeed, all attempts hitherto made in this direction have been only very partially successful.

Were it not that the number of important rock-forming minerals is small, the study of igneous solutions for geophysical purposes would be an almost hopeless task. The feldspars, the pyroxenes, the amphiboles and the micas appear to form isomorphous series and must be studied as such. They, with quartz, make up nearly 93 per cent. of the igneous rocks, nepheline, olivine, leucite, apatite, magnetite and titanium minerals substantially completing the list which enter into these rocks in sensible proportions. After the melting points of the minerals have been determined and their isomorphism has been studied, the most important research to be undertaken is that on their eutectic mixtures. Other features, however, must receive attention, such as their latent heat, ionization, viscosity and diffusivity. Immensely interesting will be the study of melts into which hydroxyl enters as a component and which may turn out to be emulsions rather than solutions. Such researches will constitute a most substantial addition to physical science and, as pointed out above, offer a good prospect for the rational classification of rocks.

Enough has been said to show how closely geophysical researches interlock. Researches at high temperatures must accompany investigations at common temperatures, physics must be supplemented by physical chemistry, mathemtaical ability of the highest order must be called upon at every step to elucidate difficulties and to draw inferences capable of being again submitted to inquiry, and some geological knowledge, too, is requisite to appreciate the bearing of results and to indicate the questions of importance. No human being has the length of days, the strength, the skill or the knowledge needed to undertake, without help, the investigation of geophysics as a whole. Only a few of the topics touched upon in the earlier pages of this essay are independent of co-operation; for instance, the astronomical conditions favorable to glaciation and perhaps the application of the mathematics of capilarity to the problem of erosion. On the other hand, the list of geophysical problems requiring co-operation could be almost indefinitely extended even now, and will be supplemented when the most pressing questions approach their answers.

Organization increases efficiency in scientific work as much as in technical pursuits, though it has seldom been attempted. Instances in point are the U. S. Geological Survey, the Reichsanstalt and astronomical surveys of the sky. Geophysics, then, is too difficult a subject to be dealt with excepting by a well organized staff, working on a definite plan resembling that indicated above. The tastes and convenience of individuals must give way to the methodical advancement of knowledge along such lines that the work of each investigator shall be of the utmost assistance to the progress of the rest.

Work in geophysics is already in progress in this country, thanks to the appreciative sympathy of director Walcott, of the Geological Survey, and the liberality of the Carnegie Institution, by members of my staff and in part under my direction. Messrs. A. L. Day and E. T. Allen have made an excellent series of determinations of the melting points of the triclinic feldspars and studied their thermal properties. They are now preparing to make experiments is aqueo- igneous fusion. Mr. C. E. Van Orstrand has made a novel application of the theory of functions to elastic problems and has reduced several series of important observations on elastic strains for comparison with theory. Dr. J. R. Benton is occupied in experimental investigation of elastic strains in various substances. The men engaged in these researches are able and devoted to their work, but they are too few in number, and they are required to make determinations of the most delicate character in an office building standing in the busiest portion of Washington, where the walls are in a state of incessant tremor and where there is no suggestion of uniformity of temperature. Under such circumstances the results of observation can not be of the most refined character and must be obtained at great expense of time and effort.

Most of the great physicists of the world have expressed their interest in geophysics and their belief that the time is ripe for its investigation. Geologists are eager for its results, but no government can undertake investigations so remote from industry as this. I do not think I can more fitly conclude this paper than by quoting a resolution introduced by Mr. S. F. Emmons at Vienna, a year ago. It was

passed by acclamation by the Geological Congress, after a ringing speech by professor Suess, and it expresses my own views most accurately.

EMMONS'S RESOLUTION.

"It is a well-known fact that many of the fundamental problems of geology, for example those concerning uplift and subsidence, mountain-making, vulcanology, the deformation and metamorphism of rocks and the genesis of ore deposits, cannot be discussed satisfactorily because of the insufficiency of chemical and physical investigations directed to their solution. Thus, the theory of large strains, either in wholly elastic or in plastic bodies, has never been elucidated; while both chemistry and physics at temperatures above a red heat are almost virgin fields.

"Not only geology but pure physics, chemistry and astronomy would greatly benefit by successful researches in these directions. Such researches, however, are of extreme difficulty. They would require great and long sustained expenditure as well as the organized co-operation of a corps of investigators. No existing university seems to be in position to prosecute such researches on an adequate scale.

"It is, therefore, in the judgment of the Council of the Congrès Géologique International, a matter of the utmost importance to the entire scientific world that some institution should found a well-equipped geophysical laboratory for the study of problems of geology involving further researches in chemistry and physics."

NOTES ON THE APICAL END OF THE SIPHUNCLE IN SOME CANADIAN ENDOCERATIDAE, WITH DESCRIPTIONS OF TWO SUPPOSED NEW SPECIES OF NANNO.

By J. F. Whiteaves, Ottawa, Ont.

PLATES II AND III.

In 1870 Barrande described and figured an obliquely annulated, cigar-shaped fossil from Phillipsburgh, which he thought was the initial part of the shell of an *Endoceras*, under the name *Orthoceras* (*Endoceras*) *marcoui*, and in 1874 he redescribed and refigured the same specimen, and called it *Endoceras marcoui*. According to Foord,* "the figures of this fossil give one the impression that it is a portion of the siphuncle, because it is marked by a series of oblique rings, which are acutely bent upward on one side." * * * "The dark space represented in the cross section," he adds, "I should judge to be one of the sheaths which occupy the cavity of the siphuncle in this genus." The figures show that the specimen is annulated to the very tip, and if it is the apical end of a siphuncle, as it certainly seems to be, it must have been entirely internal. It looks like the cast of the interior of part of the siphuncle of a *Piloceras*, and should probably be called *Piloceras marcoui*.

However this may be, in the museum of the geological survey of Canada there are several siphuncles, or portions of siphuncles, of Endoceratidae, with the apical end preserved, from the Black River limestone at one of the islands in lake Nipissing, collected by Mr. A. Murray in 1854, and a few from the same formation at Paquettes rapids, on the Ottawa river, collected many years ago by Sir W. E. Logan or E. Billings. The swollen apical end of the siphuncle in these specimens is so much like that part of the sipho in *Nanno aulema*, that they were referred to that species, by the writer, in the "Ottawa Naturalist" for September, 1898. The recent acquisition of a series of similar but much more perfect siphuncles from Kingston Mills, has, however, shown

* Catalogue of the Fossil Cephalopoda in the British Museum, Part I (1888), page 132.

that in these fossils and in those from lake Nipissing, the subsequent and prolonged portion of the siphuncle is quite different from that of the western *N. aulema.*

The same museum now contains a collection of specimens of siphuncles of at least four species of Endoceratidae with the apical end preserved, from the Cambro-Silurian rocks at various localities in Ontario and Quebec. A few of these specimens are silicified siphuncles, that are either water-worn or that have been treated with acid, but by far the greater number are mere casts of the interior of the siphuncle. The silicified specimens show the general shape of the siphuncle, and the casts the same, with the addition of more or less well defined, obliquely transverse annulations or "septal rings," and most of the structure of the interior.

In three of these specimens, the apical end of the siphuncle is not gibbous, or abruptly swollen and then suddenly contracted, on the convex inner side, as in *Nanno,* and theri generic position is uncertain. Two of them are from the Black River limestone at Paquettes rapids, and the other is from the Lorraine shales at the Don brick yard, near Toronto.

The two from Paquettes rapids, which are very different from those from that locality that had previously been referred to *Nanuo aulema*, are silicified and badly preserved.. They are both acutely pointed posteriorly, and the apex of each is eccentric, as represented by figure 1, on plate II. In external form they are not at all unlike the pointed end of the guard of a rather slender belemnite. They are, also, very similar in shape to the anterior endocone of the siphuncle of a *Vaginoceras*, like that of *V. commune*, as figured on page 514, fig. 1055 B, of Eastman's translation of Zittel's Text Book of Palaeontology. But, externally, they both show distinct traces of obliquely transverse annulations or septal rings over the greater portion of their surface, and, internally, there is a deep, funnel-shaped cavity, or endocone, at the imperfect anterior termination of each.

The specimen from the Don brick yard, which is represented, a little reduced in size, by figures 2 and 2 a on plate

II, is a cast of the interior of the greater part of a large but rather slender siphuncle, fully seven inches and a half in length, collected by Mr. Joseph Townsend in 1894. It is very slightly narrower in the long median portion than at a short distance from either end, and is obviously incomplete at the broken anterior end. Near the midlength it is rounded suboval in transverse section. Its posterior extremity, which is straight on one side, and widens rather rapidly on the other for the length of nearly an inch, is conical and pointed, with an eccentric apex. Its surface is smooth and worn, and, if there ever were any indications of obliquely transverse septal rings, they seem to have been quite obliterated prior to the fossilization of the specimen. The shales from which this siphuncle was collected, hold characteristic examples of *Endoceras proteiforme*.

In all the other isolated siphuncles of Endoceratidae in this collection, the apical end is gibbous, or swollen and then abruptly and widely but not very deeply contracted, on the convex inner side, as in *Nanno*. The subsequent portion is prolonged, longicone, moderately elongated and rather slender. These siphuncles are very similar to those of *Endoceras belemnitiforme*, as figured by Holm, though the obliquely transverse annulations on the surface of the Canadian specimens indicate that the septa were much more numerous and closely approximated, and internally their endosiphon opens anteriorly into a large and deep, funnel-shaped cavity.

If *E. belemnitiforme* be a *Vaginoceras*, as it is asserted to be by Hyatt, these siphuncles should probably be referred to that genus. But, the type of *Vaginoceras* is the *Endoceras multitubulatum* of Hall, an extremely elongated and slender species, whose apex is unknown, and it is difficult to see how *E. belemnitiforme* can belong to the same genus. Holm and Clarke both state confidently that *E. belemnitiforme* is a *Nanno*, and it therefore seems most prudent to refer all these siphuncles to that genus provisionally. Foord, it is true, has observed that portions of siphuncles are not of much use for purposes of generic or

specific determination or description, but such apparently valid genera as *Huronia*, *Discosorus*, *Deiroceras* and *Narthecoceras* have, nevertheless, been practically based upon just such specimens. Incidentally, also, it may be mentioned that the flattened outer side of the siphuncle in *Endoceras marcoui*, *E. belemnitiforme*, and *Nanno aulema*, upon which the obliquely transverse annulations are arched forward, is called the dorsal side by Barrande and Clarke, the peripheral by Holm, and the ventral by Hyatt. In this paper it will be called indifferently the peripheral, outer, or flattened side.

These siphuncles group themselves naturally into at least two species, both of which are apparently undescribed, though it is by no means certain that both belong to the same genus. One of these species is represented by a single specimen from the Calciferous of Ontario, and the other by several specimens from Kingston Mills, also, possibly, by all those siphuncles from lake Nipissing and Paquettes rapids that had previously been identified with *Nanno aulema*. These two species may be provisionally named and characterized as follows:

NANNO PRIMAEVUS, sp. nov.

PLATE II—Figs. 3 and 3 a.

Apical cone of the siphuncle, the only part known, almost straight on the flattened peripheral side, slightly swollen at a short distance from the apex on the opposite or convex side, then lightly or shallowly contracted on that side, and ultimately increasing very slowly in thickness, the commencement of the prolonged or longicone portion being nearly circular in transverse section, but also flattened on the peripheral side.

Surface of the apical portion of the endocone smooth; its anterior and contracted portion rather obliquely, and closely but faintly annulated, though the annulations, or obscure low annular ridges, appear to be interrupted on the smooth and flattened peripheral side. These annular ridges are numerous and close set, though they are unequal in size and irregular in their distances apart.

Calciferous formation at Lot 18, Con. 6, Marlborough, Ont., W. R. Billings, 1898: a silicified fragment of the posterior end of the siphuncle, about an inch and a quarter in length, with the apex broken off, but clearly showing the swelling and subsequent contraction on the inner or convex side. The interior of this fragment is not very well preserved, as the specimen has been treated with acid, which may have destroyed some of the more minute details of sculpture. The expanded portion of the praeseptal cone seems to have been composed of two thin outer layers of test, that are amalgamated or fused together, as it were, on the convex inner side, and that enclose a rather large internal cavity. The interior of the subsequent and contracted portion is nearly filled with a lining of minute quartz crystals.

This fragment seems to be the first Nanno-like siphuncle that has been found in the Calciferous formation, but it is with some hesitation that it is referred to the genus *Nanno.*

NANNO KINGSTONENSIS, sp. nov.

PLATE III—All of the figures.

Siphuncle longicone, moderately elongated and often quite slender; tumid and gibbous, or only slightly swollen near the apex and afterward rather abruptly contracted on the convex inner side, but ultimately increasing very gradually and equally on both sides. Transverse section usually subelliptical or semielliptical in outline, with the lateral diameter a little greater than the dorso-ventral; or not far from circular, but always with the peripheral region more or less flattened.

Posterior and expanded portion of the apical cone smooth; the contracted portion thereof and the whole of the siphuncle in advance of the apical cone marked with numerous, rather closely disposed, continuous and obliquely transverse annulations or "septal rings." These annulations are rather wide, flat bands, varying in width from two or three millimetres in small specimens to four or five in large ones, with faint narrow depressions or grooves between

them. They are very similar to the septal rings of the siphuncle of *Piloceras* and each of them is curved concavely and shallowly backward on the convex inner side, and forward, into a narrowly rounded, short, tongue-like process, on the flattened peripheral side.

Longitudinal sections of the praeseptal cone show very little if any structure. But, in similar sections, the prolonged portion of the siphuncle is seen to be filled with numerous and closely disposed, invaginated sheaths, and the endosiphuncle to open anteriorly into a large and deep funnel-shaped cavity, as represented in figure 4. In a specimen in which parts of the sutures of some of the septa are preserved, the sutural lines are closely approximated and about three or four millimetres apart.

External test unknown.

Railway cutting at Kingston Mills, near Kingston, Ont., Dr. R. W. Ells, W. A. Johnston, and J. F. Whiteaves, 1902: several imperfect casts of the interior of the siphuncle, and one specimen with parts of the sutures of some of the septa preserved. These casts are broken in all directions, longitudinally and transversely, and their broken ends are sometimes worn and rounded, in the matrix, evidently prior to their fossilization, but the septal rings are often remarkably well defined. The best specimens are pieces of the Nanno-like apical end, from a little over an inch to fully two inches in length, and of the subsequent prolonged or longicone portion, from two to four and a half inches in length, but in no cases have the two been found united.

The exact age of the limestone at Kingston Mills, in which these siphuncles occur, is still uncertain.

On page 178 of the Geology of Canada for 1863, it is stated that "at Kingston Mills an exposure of twelve feet in thickness, of much the same character as the lower portion of the strata" between the Potsdam sandstone and the Birdseye and Black River formation, "is seen resting on gneiss, in the excavation made for the Grand Trunk Railway. In this a fossil occurs, somewhat resembling the siphuncle of *Piloceras canadense*, but it may be a fragment of

the internal cast of the siphuncle of an *Orthoceras*. The former would seem to ally the deposit with the Calciferous formation, but a single fossil is too slight an evidence to fix its age."

Specimens of this fossil had been collected by Sir W. E. Logan at Kingston Mills in 1842, and although these can no longer be found, there is little doubt but that they are pieces of the siphuncle of *N. kingstonensis*.

The similar specimens recently collected at this locality by Dr. Ells, Mr. Johnston, and the writer, were found associated with (1) a slender and apparently undescribed species of *Actinoceras* or *Paractinoceras*, and (2) a small *Raphistoma*. The *Actinoceras* seems to have had a smooth test, and a beaded siphuncle, detached and worn segments of which are abundant as little, slightly depressed spheroids. Only one specimen of the *Raphistoma* was found, and it is too imperfect to be determined specifically, but the genus is not known to occur in rocks as old as the Calciferous. These fossils would seem to indicate that the limestone at Kingston Mills is probably not older than the Chazy formation, not much if at all newer than the Black River limestone.

The siphuncles from lake Nipissing and Paquettes rapids that were formerly referred to *Nanno aulema*, can scarcely be distinguished at present from those of *N. kingstonensis*, and if they should prove to be specifically identical therewith, the limestone at Kingston Mills may be found to be only a local phase or modification of the Black River limestone, or of part of the Birdseye and Black River formation. On the other hand, it must not be forgotten that the surface markings of the prolonged portion of the siphuncle are not at all well preserved in the specimens from lake Nipissing, and that it is only the apical end of the siphuncle that is to be seen in those from Paquettes rapids.

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THE PROGRESS OF VERTEBRATE PALAEONTOLOGY AT THE AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK.

By O. P. HAY, New York.

During the past summer professor H. F. Osborn, of the department of vertebrate palaeontology, sent out three expeditions in search of fossil mammals and reptiles. One of these, in charge of Dr. W. D. Matthew and Mr. Walter Granger, spent the season in the Bridger Eocene, in southwestern Wyoming. Special search was made for complete remains of the great horned mammal, the Uintatherium, which inhabited that region during the Eocene. As a result, two skeletons were secured and a fine lower jaw. One of these skeletons was in such a position that it appeared to have been mired in what was then a soft tenaceous clay, but is now an olive shale. There were found also a skeleton and two fine skulls of Hyrachyus, a primitive running rhinoceros; the skull and part of the skeleton of Hyopsodus, either a lemur or an insectivore; three skulls of Isectolophus, a primitive tapir; six skulls, two with portions of the skeleton, of Palaeosyops, an early type of titanothere; and two skulls of carnivores related to the dog family. There were secured also numerous jaws and other fragmentary remains representing the many kinds of small monkeys, carnivores, rodents, etc., described by professor Marsh from this formation. The Museum has now examples of almost every known species of the Bridger formation, except Tillotherium and Stylinodon; and in many cases far more complete materials than have hitherto been found. Besides these, several genera and many species which had not before been known have been secured by the museum. The fauna of this region was a surprisingly rich one, including besides mammals, many crocodiles, lizards, fishes, and numerous turtles. Diligent search was made for the fossil horse of the Bridger, but thus far only fragmentary specimens have been found, the best being a palate with a complete set of upper teeth.

In charge of the search for reptiles professor Osborn placed Mr. Barnum Brown, connected for several years with

the museum, and especially known for his successful palaeontological explorations in Patagonia and Montana. It was especially desired to secure a complete skeleton of some of the great plesiosaurs which are known to have inhabited the region west of the Missouri river during Cretaceous times. Continuing his work of 1902 and 1903, Mr. Brown made special search in the Pierre shales, with satisfactory results. From these shales near Edgemont, S. Dakota, he obtained the greater part of a plesiosaur skeleton, including skull, jaws, the complete neck about fifteen feet long, one complete paddle, part of the pectoral girdle, and some dorsal vertebrae. In the same locality there was secured another plesiosaur having skull, jaws, one complete paddle, and some vertebrae. Two other important reptilian specimens were obtained in this formation, a young plesiosaur having both girdles and two paddles; and a mosasaur with skull, jaws, and part of the skeleton uncrushed. This formation yielded twenty-two boxes of fossils.

Mr. Brown extended his exploration into the Ft. Benton formation. In 1903 he found there a complete skull of a great marine crocodile with a long snout, in a somewhat broken condition. This year a perfect specimen of the same animal was secured.

In beds near the Judith river in Montana the skeleton of a large hadrosaur named Trachodon was discovered, including pelvis, vertebral column, and limb bones.

Mr. Brown with his party then journeyed into New Mexico in search of beds which had been reported as containing large reptiles of the Jurassic age. On arrival it was found however that these beds were really of Cretaceous age, belonging to the Laramie. Here were fortunately obtained the complete skull and jaws of one of the primitive horned dinosaurs named by professor Cope Diclonius; also a large turtle.

From New Mexico Mr. Brown went into Arkansas and made search in ac revasse, explored somewhat last year, for fossil mammals of the Pleistocene period. Here were secured ten complete skulls and many fragmentary skulls of rodents and carnivores, about one thousand jaws, thousands of limb bones and vertebrae, representing nearly forty species of animals. Materials were brought to the museum for the

preparation of a section of this remarkable cave. This will show the bones as they were found in position. The animals were either washed into this cave or were dragged in by small carnivores. They include many living species of animals, such as bears, pumas, foxes, wolves, deer, beaver, rabbits, squirrels, mice, rats, bats and several kinds of birds, among them probably some extinct forms. There were discovered also remains of certain lizards, toads and frogs. The species of these animals were partly of living kinds, partly of kinds which have disappeared since this remarkable cave collection was deposited. As proof of its geological age, there were found also a skeleton of the saber-toothed tiger, recognizable although very much crushed, and the skeleton of a musk ox. Remains of a living species of peccary were also found.

The third expedition was sent into the Oligocene badlands of Cheyenne river, in South Dakota, and was in charge of Mr. A. F. Thompson of this Museum. Especial attention was to be paid to the collection of fossils from the Titanotherium beds, the fauna of which, excepting Titanotherium itself, is little known. This fauna is of especial importance, as it will enable us to connect more closely the rich Mid-Oligocene fauna with the Upper Eocene (Uinta) fauna of Utah and to determine how far the Oligocene fauna is a product of evolution from known Eocene types and how far of immigration from regions whose Eocene fauna is not yet discovered.

Mr. Thompson had considerable success in the Titanotherium beds, and secured some excellent specimens from the Oreodon beds also. The collection includes skulls and fragmentary skeletons of at least three new genera, two titanothere skulls, seven rhinoceros skulls, and various other specimens of less importance, but representing several new species. Three fine specimens of turtles were secured, two of which are new. The number of catalogued specimens is 125.

The curator of the department of vertebrate palaeontology, Prof. H. F. Osborn, spent a portion of the summer in Europe, visiting various museums and attending the Zoological Congress at Bern and the meeting of the British Asso-

ciation for the Advancement of Science, in England. The writer also attended the Congress at Bern and visited many museums on the continent and at London, examining especially the fossil turtles.

THE COMPARATIVE ACCURACY OF THE METHODS FOR DETERMINING THE PERCENTAGES OF THE SEVERAL COMPONENTS OF AN IGNEOUS ROCK.

By IRA A. WILLIAMS, Ames, Iowa.

The object of this paper is to present the results of a series of determinations of the quantitative mineral composition of an igneous rock. These determinations were made according to the various methods that have heretofore been employed by different investigators in estimating the relative proportions of the constituents of igneous rocks. The work was done at Columbia University where the writer was at the time Fellow in Geology. Not all of the methods employed, however, are equally applicable to both the thoroly crystalline and the porphyritic rocks; while with the glasses and felsytes no accurate estimate of composition can be made by any means except chemical analysis.

The methods used may be listed: (a) calculation of mineral composition from the chemical analysis of the rock; (b) separation of the mineral grains of the crushed sample according to their specific gravity by Thoulet's solution; (c) the method based on the microscopic measurement of the diameters of grains in thin sections; (d) that based on the microscopic measurement of the areas of the grains in thin sections; (e) photographing microscopic fields, then cutting out and weighing from prints thus secured the areas of the various constituents; (f) calculation of volume percentages from the data obtained by the foregoing microscopic methods.

In order to obtain results admitting of comparison, it was necessary at the outset to select a rock to which each of these several methods could be applied. The rock must therefore be a holocrystalline one. The coarser the grain, moreover, and the more clear cut and distinct the boundaries

of the minerals, the more nearly ideal is the sample for the purpose in view. More important still, perhaps, is the requirement that the minerals themselves be such that each and every grain can be readily and certainly recognized at a glance under the microscope. The misidentification of a grain, or of a few grains in a field, especially if the rock be coarse textured, is certain to afford results that are more or less incorrect.

After some preliminary and unsatisfactory experiments with the Palisade diabase from New Jersey and a nephelite syenyte from Red Hill, New Hampshire, the rock finally selected was the pink granite from Westerly, Rhode Island.* The Westerly granite is moderately coarse-grained as a rule, and unusually so in places. The individual grains of the principal minerals range from 1.5 to 5 mm. in diameter.

Professor J. F. Kemp in the paper cited gives a complete description of the rock and enumerates the essential and accessory minerals which compose it. Under the microscope the following minerals are recognizable in practically every field. Orthoclase, often showing the reticulated structure of microcline, a plagioclase, near oligoclase, quartz, magnetite. A little muscovite and apatite occur, but so far as their presence is concerned in the percentage composition of the rock as a whole, can be neglected. Biotite is a normal constituent but in the sample worked with was present in only very subordinate amount. Other more rare accessories occur but are neglected in the present study.

The anhedra of quartz and the feldspars are predominantly distinct, one not including the other as a rule. In some slides, however, the quartz is sometimes broken up into smaller rounded grains which are frequently included in the feldspars. The boundaries in these cases are not so sharply defined and the necessity of taking into account numerous small particles of one mineral in a groundmass, as it were, of a large grain of another, involves of course chance of inaccuracy. As with the Palisade diabase and the New Hampshire syenyte, there arose the question of being able to always distinguish between the feldspars. It was believed

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*J. F. Kemp, Granites of Southern Rhode Island, with Observations on Atlantic Coast Granites in General. *Bull Geol. Soc. Amer.*, Vol 10, 1899, p. 362.

unsafe to undertake to do this with the microscope so they were lumped together under the general head feldspar. The different species were separable with Thoulet's solution, so that by this means the granite was separated into quartz, orthoclase, oligiclase, and iron ores; while with the microscope alone but three groups could be made, viz., quartz, feldspar, ores.

(a). METHOD BY CHEMICAL ANALYSIS.

The chemical composition of the Westerly granite as given in professor Kemp's article follows:

SiO^2	73.05 per cent.
Al^2O^3	14.53 per cent.
Fe^2O^3 } FeO	2.96 per cent.
MnO	Trace.
CaO	2.06 per cent.
MgO	Trace.
K^2O	5.39 per cent.
Na^2O	1.72 per cent.
H^2O	.29 per cent.
	100.00

Calculation of the standard mineral composition by the method of Cross-Iddings-Pirsson-Washington, as set forth in their "Quantitative Classification of Igneous Rocks," from this analysis, was not possible in all desired detail because the two oxides of iron were determined together. Although the total iron is not high and in this individual instance would likely make little difference in the results whether treated as all Fe^2O^3 or FeO, the fact that considerable magnetite was present as well as lesser proportions of the magnesium-iron-silicates made it seem desirable to have a new analysis in which the two oxides of iron would be separated. It is also especially important that all the other tests be made upon the identical specimen from which the sample for chemical analysis is taken. The following analysis was made by the writer, under the helpful guidance of Dr. H. S. Washington, in the chemical laboratory of the Department of Geology, Columbia University. The rarer elements were not determined as the object of the analysis did not require them:

SiO^2	72.26 per cent.
Al^2O^3	13.58 per cent.
Fe^2O^3	2.97 per cent.
FeO	0.75 per cent.
MgO	0.034 per cent.
CaO	1.24 per cent.
Na^2O	2.18 per cent.
K^2O	5.69 per cent.
H^2O+	0.57 per cent.
H^2O-	0.09 per cent.
	99.364

Calculation from this analysis yields the following approximate mineral composition:

Quartz	35.90 per cent.	Biotite	0.255 per cent.
Orthoclase	34.48 per cent.	Magnetite	2.605 per cent.
Albite	18.74 per cent.	Hematite	1.10 per cent.
Anorthite	6.25 per cent.	H^2O+	0.095 per cent.
H^2O-	0.577 per cent.		
		Total	100.002 per cent.

The small amount of biotite, which would not result directly in calculating the norm, it was found convenient to bring in to take care of a small excess of alumina and the little MgO that appears in the analysis. Inspection of these results shows a total feldspar percentage of 59.47 of which 24.99 is plagioclase. The total for those minerals, viz., biotite, magnetite and hematite, which, in both microscopic and heavy solution analysis, are grouped as "iron ores," is here 3.96 per cent.

(b). HEAVY SOLUTION METHOD

Thoulet's* solution was used in the present experiments. It is made by dissolving in cold water potassium and mercuric iodide, KI and HgI^2, in the ratio 1 : 1.24. This gives a clear greenish-yellow liquid, the depth of color depending on the degree of concentration. Moderate heating does not affect it, so that its density can be increased or diminished to any desired point.

A description of the apparatus employed in making separations may be found in Rosenbusch's work.† The one

*For details regarding this solution, see H. Rosenbusch's Mikroscopische Physiographie, ed. 1892, pp. 231-235; and the English Translation by Iddings, pp. 100-101.

†See also W. J. Sollas, Contributions to a Knowledge of the Granites of Leinster, *Trans. Royal Irish Acad.* Vol. xxix. pt. xiv. p. 427.

made use of in this instance is known as Brögger's modification of Harada's apparatus. It consists of an elongated pear-shaped glass vessel closed at the top with a ground glass stopper and provided with two glass cocks, one about midway the length of the vessel and another near its bottom end.

Some experiments were first made to ascertain the necessary fineness of crushing and the losses in fine powder. By carefully crushing in a steel mortar (not pulverizing) a small sample of the Palisade diabase to pass a 20-mesh sieve, and then washing out the fine dust that would float indefinitely in water, a loss of nearly four per cent was sustained. At this mesh the minerals were very imperfectly separated. Crushing to 40-mesh nearly tripled this loss. The Red hill syenyte treated in the same manner gave a loss at 20-mesh of but two per cent. While at 40-mesh this was increased to quite 10 per cent. After washing out the flour, an analysis of the 20-mesh rock gave,—84.75 per cent of the light colored minerals, orthoclase, nephelite and sodalite, and 15.25 of hornblende. The 40-mesh rock gave,—81.35 of the light colored minerals and 18.65 of hornblende. These figures would indicate a more than proportional loss of the lighter constituents.

It was found that with the Westerly granite a fair degree of separation was accomplished by crushing to 40-mesh, without a loss of over four per cent in fines. This was possible only with extreme care in crushing and by constant screening of the crushed material from the mortar without permitting any considerable portion to accumulate. The rock was first hammered to about pea size and only a few pieces put into the mortar at a time. After screening it was washed by stirring in water, allowing to stand, then decanting.

In the present experiments, mineral fragments were used for indicators and were obtained from the granite itself. A few grains of each of the minerals to be separated were placed in the solution which was then diluted till the lighter rose and the heavier ones sank. If the specific gravities of the two were near to each other the point of separation

would have a definite position which could not be varied. If, however, there happen to be a considerable range between whose limits the pure minerals will respectively rise and sink, in other words, between the specific gravities of the two minerals in question, the density of the solution may be adjusted to any position within these limits and yet give a perfect separation if the minerals are pure and entirely apart from each other. That they are never entirely freed from one another in breaking up a crystalline rock need not be emphasized. There are always particles of one clinging to every other and it is usually impossible to say whether or not more of one clings to a second than of the second to the first. By moving the density of the solution therefore nearer that of one mineral than of another to be separated from it, more or fewer of the particles composed of parts of each will be shifted one way or the other with consequent modification of results.

The only feasible plan that appears to avoid some of the discrepancies that are apt to arise in this connection is to first estimate approximately the relative proportions of the minerals by means of the microscope, or, the heavy solution itself. Then, assuming, unless accurate data can be obtained, that equal portions of the minerals cling to each other, adjust the specific gravity of the heavy solution to a position between the extremes determined by the relative proportions of the two minerals in the rock.

This same factor becomes of increasing importance in the separation of minerals whose specific gravities are very nearly alike if by any outside influence, the heat of the body, or a draught of air, the density of the solution is altered ever so slightly during a separation. Precautions are necessary to maintain surrounding conditions constant.

The facts just pointed out militate against the scientific accuracy of the heavy solution method for making quantitative separations of mixtures of minerals. Rosenbusch sums up the reasons why the method cannot be accurate in the following:*

1. The impossibility of preparing a powder which shall consist of nothing but homogeneous grains;

*Iddings' Translation, 1900, p. 107. German Edition, p. 249.

2. The variation in the specific gravity of the constituents;

3. The change of specific gravity which minerals experience through weathering, decomposition and alteration.

A 5-gram sample of the rock was found to work well in the size of separator used. After pouring in the solution, whose density was first adjusted to separate the feldspar group from the remaining heavy minerals, the weighed rock sample was added. The apparatus was thoroughly shaken and allowed to stand until a separation had taken place. The floating feldspars were then poured onto a filter, washed, dried and weighed. The residue was likewise removed and kept to be treated later. After adjustment of the density of the solution, the feldspars were parted from each other and weighed. The method of procedure in this and in separating quartz from the iron minerals was precisely as outlined above.

Three separate analyses of the granite were made. The average is tabulated in the summary near the close of the paper.

GRAPHIC ANALYSIS

The term "graphic analysis" is suggested by Dr. A. A. Julien* as a general heading to embrace all the various processes involved in estimating mineral composition in the thin section. Since the process of Delesse* was one depending on tracing the outlines of mineral grains on the polished hand specimen, this it would seem may also legitimately be included under "graphic" methods. The method of Jevon, of direct comparison of the breadth of grains by applying a scale to a polished face, may also be mentioned here.

(c). MEASUREMENT OF DIAMETER OF GRAINS.

As stated at the opening of this paper, there are three different processes which can be carried out by means of the microscope to obtain a basis for estimating the mineral composition of igneous rocks. First, the average diameters of the grains of the different minerals may be found by measuring the length of the cross section in thin slices of the

*Genesis of the Amphibole Schists and Serpentines of Manhattan Island, New York. *Bull. Geol. Soc. Amer.*, Vol. 14, p. 460.

* Procedé Mecanique pour determiner La Composition des Roches. Paris, 1866. *Annales des Mines*, (4), Vol. XIII., 1848, p. 379. *Compte Rendu* Vol. XXV, 1847, p. 544.

rock. This is accomplished by A. Rosiwal† by successive application of an eye-piece micrometer to each of a series of lines on the cover glass of the section. The width of each grain crossed by the line is recorded in micrometer divisions from which the relative cross sections of the minerals can be deduced. Uniformity in direction or any specified system of drawing these lines for measurement is shown by Rosiwal to be unnecessary. They may be curved or irregularly drawn over the section so long as the stipulation is fulfilled that, in order to obtain the correct relations of the mineral constituents in a rock, a distance at least 100 times the average diameter of the grains must be covered. For a uniformly crystallized rock a rectangular network of lines will answer. Or, two or more series of parallel lines intersecting at oblique angles give equally concordant results.

To calculate from data obtained in this way the quantitative relations of the minerals it is assumed by Rosiwal that these measurements represent average diameters and that the ratio between them is the same as between volumes. Percentage composition is thus expressed in terms of the volumes of minerals. (These are of course readily transferable to weight percentages by multiplying by the specific gravities of the minerals.)

Dr. Julien has since called attention to the fact that while concordant results may be obtained by this method, the diameters are by no means proportional to volumes whether the grains are conceived as cubical or spherical; and that the true composition can be based only on the cube of the diameter, d, in the case of generally cubical grains and on that function of the diameter representing volume, $.523d^3$, if they are spherical. In granitoid rocks that have not suffered from shearing or other dynamic action, the grains may, according to this writer, be considered as predominantly cubical or spherical according as they appear angular or have rounded outlines. Under this assumption it is clear the only true expressions for volumes are d^3 and $.5236d^3$ as stated.

†Ueber geometrische Gesteinsanalysen. *Verh Wien Geol Reichsanstalt.* vol. 32, 1898, pp. 143-175.

Now it is very apparent that if expressed in terms of diameters the percentage proportions will be very different from the values if calculated over into geometrical volumes. This disagreement between the two is surprising, and, as will be illustrated later, is so far from what might at first be anticipated, that one is led to reflect upon the validity of the first fundamental assumptions in the measurement of d and in treating the grains as cubes or spheres. Granting, however, for the moment that this last assumption of the cubic or spheric form is permissible, we may ask whether it is safe to say that the average dimension of a large number of cubes, promiscuously packed together will be the length of one edge of a cube of average volume. It seems fully as probable that it may represent an average diagonal or perhaps more likely still a value intermediate between these limits; but it may be greater or less than the length of the edge of a cube. Volumes calculated on this basis would be misleading. On the supposition of spherical bodies, d is taken as the width of the greatest section it is possible to get in slicing a sphere.

Even though the absolute volumes may not be correct using d as indicated, relative volumes as expressed in percentages may nevertheless give as significant results as if the actual value of d were known. It appears therefore that if the conception of these geometric bodies were a correct one the above absolute errors would enter; but it is believed that they would not be of sufficient magnitude to alter the general conclusions to any great extent.

The question of doubt returns then to the permissibility of assuming cubical or spherical shape for the grains of any crystalline igneous rock. While in instances, as some granites, the angular boundaries of the predominant mineral may be evident and its form could be considered roughly cubical, those secondary in quantity may be rounded or irregular. Should the prevailing mineral possess a generally rounded form and be fairly uniform in size, those constituents which fill the interstices certainly would not be correctly estimated by use of the formula for the sphere. These simple cases are far less common than the many in which no two types of minerals are similar in shape nor the grains of any

one nearly uniform in size. This fact cannot but be emphasized by examining a thin section of almost any granular rock.

To carry out this system of measurement Rosiwal recommends that the section be very thin, as nearly a plane as possible. A number of sections should be examined to obtain a representative average. It is also desirable to have the sections as large as can be conveniently made. In the present study, series of fine ink lines were drawn on the cover glass to use as indicatrices. The average percentage composition calculated from the data obtained in a study of three thin sections is included in the summary table. From the calculated composition the variety of plagioclase falls in the oligoclase group, about Ab^3 An^1. This identification is corroborated by the microscope. The typical specific gravities of the minerals are then employed for transferring to weight percentages, viz., quartz, 2.65, orthoclase, 2.56, oligoclase, 2.64, and for the iron ores, 5.25, that of magnetite.

The next method mentioned in the introductory outline is the measurement of the areas of the mineral grains in thin sections. This may be done in three ways. (1) drawing the outlines of the grains with the aid of the camera lucida. As used by W. J. Sollas*, this method is the application of the Delesse process with the microscope.

(e). PHOTOGRAPHING AND CUTTING OUT AREAS OF GRAINS.

(2) Making photomicrographs of several fields in the slide, dissecting prints thus obtained, then weighing the pieces of paper representing the areas of the constituent minerals. Photomicrographs were made of six successive fields from one large rock section. Although the magnifying power of the objective used was but medium so as to avoid distortion and also to include as large an area as possible, the focusing distance above the eye-piece was adjusted so as to get an image approximately 420 times the actual size. The Nicols were set at such an angle to each other that the contrast in coloration was strong enough to definitely outline the grains and yet not enough to seriously

*Contribution to a Knowledge of the Granites of Leinster, *Trans Royal Irish Acad.* Vol. XXIX, pt. XIV, p. 471.

darken the field. In a few instances it was necessary to refer to the section to establish the identity of certain grains in the prints. The various minerals in each of the six prints were trimmed apart and weighed. These weights, following the methods of Delesse and Sollas, were assumed proportional to the areas and hence to the volumes of the minerals, and the percentage composition computed as before. The average composition of the six fields by weight is included in the table.

(3) MICROSCOPIC MEASUREMENT OF AREAS OF GRAINS.

The third process mentioned consists in directly measuring the area of each grain of the minerals of a section with the microscope. This is done by the application of an eye-piece micrometer which is cross ruled into numerous small squares. The number of these squares coming within the boundaries of each grain in a field is counted. The areal proportions of the cross sections of the minerals are thus obtained. The fields for measurement are to be contiguous and taken in regular order in a given direction across the section; the slide being moved by means of a mechanical stage successively the width of a field as each is measured.

The data given below were obtained with fields of 4 millimetres actual diameter, and a magnification of 30. The basis of the calculations is here again the assumption that the average cross section area is proportional to volumes.

MINERAL COMPONENTS	MINERAL COMPOSITION BY WEIGHT DETERMINED BY						
	Calc. from Chem Anal.	Heavy Solution	Meas. of Diameter d	Calc. of d^3 from last	Photography	Meas. of Areas d^2	Calc. of d^3 from last
Quartz	35.90	34.25	19.025	1.406	23.23	19 901	12.14
Orthoclase	34.48	32 465	43.645	56.04	43.64	43.67	40,92
Albite	18 74	26.905	32.897	42.24	32.90	32.896	37.81
Anorthite	6.25						
Mica	2.55	5.68	4.43	0.31	0.25	3.525	0.68
Magnetite	2.605						
Hematite	1.10						

In this array of results for the mineral analysis of a single rock, the most striking comparison is, perhaps, between the heavy solution and chemical analysis as one group, and the microscopic methods as a group by themselves. The re-

sults obtained by Thoulet's solution and by calculation from the chemical composition agree in a general way and their being the only ones based primarily on specific gravity makes their accordance a strongly significant fact in considering which of the methods most nearly approximates the truth. The chemical analysis of a comparatively simple rock whose minerals components are of definite molecular proportions cannot but give a close indication of the actual or 'modal' composition. It is of course more significant if, as with the rock in hand, certain of the elements determined in the chemical analysis are limited to a single mineral. For example, potash occurs in orthoclase only and since the orthoclose molecule is a fixed one, this oxide, K^2O., determines beyond question the percentage of orthoclase in the rock. When one or more of the chemical constituents are to be apportioned among two or more minerals, and especially when these minerals are not of fixed composition, the accuracy of the results becomes less.

The Westerly granite represents a fairly simple type of composition and its calculated mineral analysis may be taken therefore as being correspondingly accurate. The general agreement of the heavy solution analysis with the calculated composition certainly suggests an approach to the truth, despite the unavoidable irregularities attending the use of the former.

Of the microscopic, it is difficult to say which method will ordinarily furnish results of the greatest value. The use of photography eliminates to a degree the personal factor and may perhaps often be employed advantageously. It is needless to call attention further to the inconsistency of calculating percentage composition by using d^3 when d is the measured width of the mineral grains as they appear in thin section.

The closest agreement of any two members of the table is noted between the direct measurement of d and of area. Were the second calculated from the first by squaring the values found for d and reducing to 100 per cent, the difference would be far greater, which may be taken as indicating that the d measured cannot be safely assumed as the first dimension of a cube; and therefore, which is evident, that

the areas measured are not d^2 but quite different in the rock under consideration.

The results of this brief study as to the efficiency of the methods employed cannot be offered as conclusive. They are such, however, as to emphasize the various phases of these methods and to indicate in a general way their limitations.

Calculation of the mineral composition from the chemical analysis affords a means of classification of rocks and, in the case of holocrystalline rocks, of expressing more or less accurately their actual quantitative mineral constitution.

Heavy solutions are a convenient and readily applicable means of separating the minerals of a rock and may be valuable in determining quantitative relations acording to the state of aggregation of these minerals and the range of specific grvaity represented. The accuracy of the results will be directly proportional to the coarseness of grain and the readiness with which the minerals can be separated. . The necessary fineness of comminution and consequent loss as dust depend on the latter condition. The time required to make a separation of a rock bearing the average number of important minerals is but a small fraction of that needed for a chemical analysis.

Any one of the direct measurements with the microscope does not appear to fulfill even approximately the necessary conditions for a statement of the complete quantitative composition of an igneous rock such as granite. They are easily applied, however, and may serve an excellent purpose in giving an idea of the comparative abundance of the constituents of a rock whether granitoid or porphyritic. But as a basis for estimating the weight, or even volume composition, the present study has shown none of them to be all that could be desired.

THE ORIGIN OF BITUMEN*

BY W. C MORGAN, Instructor in Chemistry, U C., Berkeley, Cal.

From the early decades of the last century when the first chemical investigations were undertaken in this direc-

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tion, hardly any scientific question has been debated more vigorously than that as to the origin of bitumens. Now that the industry has assumed such commercial importance the interest has not lessened. Natural gas, liquid petroleum and solid asphalt are universally admitted to have been derived from a common source, their existence in these varied forms to-day being due partly to a process of natural separation based on different degrees of volatility and specific gravity, and partly due to chemical changes wrought by water, air, heat and pressure. While each of these substances was formerly thought to be of fairly simple composition, extended investigation has demonstrated that each is in reality a very complex mixture of many individual compounds often of widely different chemical nature.

The various theories that have been put forth to explain their origin may be conveniently classed as mineral, vegetable and animal, since in each of these "three kingdoms" it is believed that a sufficient cause may be found.

Berthellot first started the mineral theory by announcing the possibility of deriving certain constituents of natural gas and oil by the action of steam and carbon dioxide on various metals hypothetically existing in the interior of the earth. This hypothesis was later elaborated by Mendeleeff and Moissan and made to include carbides of various metals which, according to the nebular hypothesis, must have been a very characteristic class of compounds at one stage of the earth's cooling process. Although these carbides are found nowhere in the earth to-day, their existence in meteorites in small quantities is supposed to give support to the theory and the laboratory production by this means of gaseous and oily products that will burn demonstrated this possibility as suggestively as does the generation of acetylene from calcium carbide. The fact that the natural products have quite a different chemical nature from the artificial product is accounted for as a modification due to ages of "storing away" in the earth's crust.

The possibility of such an origin cannot be denied. Its probability is not great. It is not a question of what might have happened but of what has actually taken place that primarily interests investigators in this field, and scarcely a

scientist familiar with the question from a geological as well as the chemical side can be found to support this theory.

The almost universal association of bitumen with animal and vegetable remains has led to the assumption of such material as the source from which it has been derived. For many years the adherents of these two theories maintained mutually exclusive positions, but wider investigation of the natural deposits seems to indicate on the one hand that bitumen has been formed from both of these sources and deeper investigations into the nature of animal and vegetable tissue have shown them to be very closely analogous. Hence a fusion of these two views has taken place in what is known as the theory of organic origin.

Various experiments have been made in the laboratory or factory with the idea of obtaining support for these theories or in the hope that a cheap method of manufacturing petroleum might be discovered. About the middle of the century Warren made a soap out of fish oil by heating it with lime in a manner entirely analogous to the way in which fat is boiled with potash or soda lye in making ordinary soap. By distilling this soap under pressure he obtained an oil containing the same kinds of bodies as are found in Pennsylvania petroleum. Later Engler distilled the fish oil itself and obtained a "light distillate" that could not be differentiated from a similar "light fraction" from natural oils. Some of this product was actually sold on the market. From linseed oil similarly treated Sadtler obtained a mixture of hydrocarbons which, on distillation, gave a light oil similar to Pennsylvania oil and left behind a vaseline residue containing paraffine. Further Day prepared asphalt-like material by distilling wood chips, herring or a mixture of both and "cracking" the distillate at high temperatures. Thus it is apparent that the results of experimentation support any theory and the artificial production indicates only the possibilities and not necessarily the realities as to the origin of bitumens.

Furthermore every case of artificial production of bituminous matter, whether from animal, vegetable or mineral material has required a temperature much beyond the

ordinary condition. An examination of the natural deposits, however, generally indicates the improbability of a previously highly heated state and in some instances even the impossibility of such a condition. We cannot assume the existence of conditions generally prevalent within the earth which may be considered to duplicate those required in the artificial production of bitumens. Quite the contrary the burden of proof rests upon him that would maintain that the laboratory apparatus and its conditions are not in all probability extremely unlike natural conditions.

Under these circumstances much time and thought have been expended in the endeavor to ascertain whether unquestioned evidence could not be obtained to show from what kind of matter natural deposits have been derived. Hence many natural deposits have been carefully studied, and while many things point to one origin or another, the evidence can hardly be considered as conclusive. Thus Wall pronounced the celebrated "pitch lake" of Trinidad to be of vegetable origin because of remains of vegetation in all stages of change present in the pitch. Jones found in the same pitch unquestionable animal remains; hence such an origin is at least not improbable. Later Richardson examined the "lake" and concluded that it was of inorganic origin.

Fraas observed petroleum oozing from a coral reef in the Red Sea and concluded that the coral polyps are to-day being changed into bitumen. Binney noticed the same phenomenon about a peat bog in England and concluded that the peat is being decomposed at the present time into petroleum. Both of these are isolated instances. No other known coral reefs or peat bogs show evidence of similar changes although conditions seem to be identical. Neither occurrence was thoroughly studied to ascertain what evidence might be found indicating another origin.

The occurrence of bitumen in fossils has hitherto been of no value as a means of furnishing direct evidence as to its origin inasmuch as investigation proves that the bitumen need not, and often could not, have been derived from the organism with the remains of which it is to-day associated The discovery of a fossil egg, partly filled with asphalt, in

which all evidence points unequivocally to the fact that the asphalt has been derived from the natural contents of the egg, is considered of scientific value inasmuch as it is the first case in which the kind of material from which bituminous matter has actually been formed can be definitely proven. Since an egg contains in concentrated form material like that constituting animal tissue, the actual derivation of bitumen from animal remains is thus proven. Moreover everything about this specimen indicates strongly that it has never been much higher than ordinary temperature, hence natural conditions are thus demonstrated to be sufficient to transform animal matter into bitumen during long periods of time without the aid of heat. This discovery does not necessarily mean, however, that some petroleums have not been derived from other than animal sources.

DEVELOPMENT AND MORPHOLOGY OF FENESTELLA.*

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Thin sections and serial sections of exceptionally well-preserved bases of *Fenestella* (*Semicoscininm* of authors) from the Hamilton of Thedford, Ontario, show the exact size and shape of the primary zoœcium (*protoecium*) and the morphology and orientation of the primary buds. The protœcium consists of an elongate tubular zoœcium with a very large basal disc. It is without hemisepta. Morphologically it is strictly comparable to the protœcium of Cyclostomata (of *tubulipora*, *chenopora* &c.) The two primary buds arise from the dorsal face of the protœcium ,usually just above the basal disc, and are very symmetrically orientated with reference to the dorso-ventral plane. They are of about the same shape as the protœcium and somewhat smaller. Each of these buds produces a single bud in the first tier, and an additional bud arising from one of the latter completes the first tier of buds—six zoœcia including the protœcium. Zoœcia of the shape characteristic of the adult *Fenestella* colony do

* Abstract of a paper read at the Philadelphia meeting, G. S. A., Dec., 1904.

not appear till the colony begins to branch. Hemisepta have not been seen in any of the earlier zoœcia. These studies seem to definitely relate *Fenestella* genetically to the Cyclostomata. The Cyclostomata are therefore the ancestors of the Cryptostomata and through them of the Chilostomata.

PLEISTOCENE HISTORY OF FISHERS ISLAND, N. Y.*

MYRON L. FULLER, Washington, D. C.

Fishers island, which is located several miles southeast of New London, Connecticut, is not, as has been previously supposed, a simple morainal island. On the contrary the morainal deposits of the last, or Wisconsin, ice invasion, are generally only a very few feet in thickness, the great mass of the island being made up of material deposited during earlier ice advances or interglacial stages. The oldest formation definitely recognized on the island is the thick bed of clay which is well exposed at the big clay pit. This merges upward without unconformity into a series of sands and fine gravels, the whole being later thrust up into folds of considerable hight. The folded deposits were subsequently deeply eroded, but were covered again up to a certain altitude by horizontal sands and gravels deposited during a later ice invasion. These were in turn eroded by streams before the advent of the last ice sheet, which left a thin mantle of till and otherwise slightly modified the surface at certain points. The various formations are correlated with similar beds on Long island on the west, and on Block, Marthas Vineyard and Nantucket islands on the east. The clay and the overlying conformable sands are assigned to the Yarmouth interglacial stage, the folding to the Illinoian, and the horizontal (Tisbury) sands to the Iowan glacial stage.

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* Abstract of a paper read at the Philadelphia meeting. G. S. A., Dec., 1904.

SOME DRAINAGE FEATURES OF SOUTHERN CENTRAL N. Y.*

R. S. TARR, Ithaca, N. Y.

In many instances along the divide between the Susquehanna and St. Lawrence drainage systems there is a condition of lowered divides, across some of which, as in the Tioughnioga valley, east of Cortland, and the Cayuta creek valley, west and south of Van Etten, the present drainage passes. Three theories are discussed to account for these phenomena, glacial erosion; erosion by ice fed stream; and headwater erosion during rejuvenation. Evidence from valley form, glacial deposits, and hanging tributary valleys is presented to prove that these drainage features are in many cases, if not in all, due to changes of earlier date than the advance of the Wisconsin ice sheet. While the influence of possible earlier ice advances, of which no evidence has been found in this region, is not eliminated, the facts so far discovered favor the hypothesis of rejuvenation rather than of glacial action during earlier ice advance.

MOUNTAIN GROWTH AND MOUNTAIN STRUCTURE.*

BAILEY WILLIS, Washington, D. C.

The study of peneplains at various altitudes with reference to sea level in North America and Eurasia, demonstrates that elevations of the earth's surface have resulted from deformation which occasioned warping of previously planed surfaces. Observations of the effects of erosion in the elevated masses show that the process has in general been a recent one, post-Mesozoic, and has justified Powell's generalization that mountains are youthful features of the earth.

The study of the mechanics, physics, and chemistry of rock deformation has shown that the structures discovered

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* Abstract of a paper read at the Philadelphia meeting, G. S. A., Dec., 1904.

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in mountain masses are such as develop only under considerable load of rock, and consequently at notable depths in the earth's mass.

A comparison of the relative positions of peneplains and depth of structure leads to the conclusion that the mountain masses must have been more deeply buried at the time of development of the structure than they can have been since the date of peneplanation. Consequently, between the deformation which resulted in the structure and the accomplishment of peneplanation there must have elapsed a period of erosion of greater or less time.

It follows that modern mountains are not the effects of those forces which produced the structures. This conclusion cuts at the foundation of the older systems of classification of mountains.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Indiana Department of Geology and Natural Resources. Twenty-Eighth Annual Report. W. S. BLATCHLEY, State Geologist, 1903.

This volume maintains the high standard set by former reports issued by Mr. Blatchley. The geological map which accompanies it is a notable addition to Indiana geology and is worthy of all praise. For the first time, Indiana has a geological map worthy of the name.

The report contains the following chapters: The Geological Map of Indiana, by T. C. Hopkins; A short description of the Topography of Indiana, and of the rocks of the different geological periods of the state, by T. C. Hopkins and A. F. Foerste; The Petroleum industry of Indiana in 1903, by W. S. Blatchley; The Lime industry of Indiana in 1903, by W. S. Blatchley; Report of the state mine inspector for 1903, by James Epperson; Report of the state gas supervisor for 1903, by B. A. Kinney; A Physiographic and Ecological study of Winona lake region, by W. M. Mills; The Stratigraphy and Paleontology of the Niagara of northern Indiana, by E. M. Kindle; Contents of and Index to volumes I. to XXVIII. of the reports of the Indiana Geological Survey, by T. C. Hopkins.

The detailed field-work for the geological map has all been done during the incumbency of Mr. Blatchley and is in the main of a high order of accuracy. Future studies will make some changes in the Knobstone-Harrodsburgh boundary and several outlying

areas of Silurian rocks in the southeastern counties have yet to be delineated. The nomenclature of formations as it appears on the map and in recent Indiana reports is open to some criticism. The term Bedford is objectionable for reasons pointed out by the reviewer and others several years ago. At that time the term *Salem* limestone was suggested for the formation and was subsequently sanctioned by the U. S. Geological Survey in preference to Bedford on substantially the grounds urged by the reviewer that Bedford is the name of a well known, well charcterized, and widely distributed formation in Ohio. Notwithstanding these patent facts, the Indiana survey has retained the term Bedford and introduced a still more objectionable duplication of names in the term "Huron formation" applied to rocks formerly known as Kaskaskia. This use of the term Huron is due to Messrs. Hopkins and Ashley. The Huron, again, is a name long used by Ohio and Michigan geologists for a Devonian formation much better characterized in every way than the Indiana formation in question. It was proposed by Winchell in the First Biennial Report of the Michigan Geological Survey in 1861. Only confusion can result from such duplication of names.

In the discussion of the Ordovician stratigraphy the reviewer notes that Mr. Foerste employs several of the faunal designations of the sub-divisions of the Ordovician of Indiana, proposed by him in 1899, namely *Dalmanella multisecta* zone for the Utica, *Rafinesquina alternata* zone for the upper Lorraine and *Dalmanella meeki* zone (*D. jugosa* of Foerste) for the lower Richmond. These faunal designations are eminently proper and much more workable than the Bryozoan zones proposed by Nickles. The difficulty of identifying the Trepostomata in the field will always render them of limited value to the stratigrapher. Any faunal designation of the divisions of the middle and upper Richmond at the present time is premature owing to the small amount of detailed study that has been bestowed upon this interesting series of rocks. The faunules of the Richmond seem to be of much more limited distribution than those of the Utica and Lorraine.

In the chapter on petroleum Mr. Blatchley again calls attention to the many erroneous notions current among drillers and investors in regard to the occurrence and supply of petroleum.

A noteworthy contribution to Indiana paleontology is Dr. Kindle's careful analysis of the faunas of the Niagara of northern Indiana. This paper is illustrated by excellent figures of the species considered. The author also describes the quaquaversal dips of the Niagara rocks of the northern area, and concludes that they have been produced in a way similar to the formation of mud lumps in the Mississippi delta, as recently described by Harris.

E. R. C.

The Geology of the San José District, **Tamaulipas, Mexico. By Geo. I. Finlay. (Contributions from the Geological Department of Columbia University, vol. xi. No. 100.)**

In December of 1901, Mr. Finlay went to San José, Mexico, for the purpose of studying the copper ore and eruptive rocks of that district; this paper gives the result of his investigations of the eruptives.

The town of San José lies in a spacious amphitheatre which is enclosed on three sides, the north, east and west, by limestone mountains. Between these mountains the drainage of the valley finds an outlet to the north and east. The hight of the peaks varies from 3,000 to 3,500 which is about 1,000 feet above the valley level. The Baril range closes the valley on the south and forms a divide between the San José valley and that of the Arroyo Grande to the south.

The valley climate approaches aridity; the rain supply of the year is concentrated in one or two weeks and finds its way to the streams at once, and with little diminution from ground storage, converting them into torrents and intensifying corrasion. V-shaped valleys and steep slopes result from these climatic conditions.

The stratigraphic relations of the rock formations are as follows: Underlying the town of San José and surrounding district is a laccolitic mass of andesyte which has intruded into limestone and shale on the north, east and west, and into nephelite syenyte to the south. The limestone cover has been almost wholly removed by erosion but the quaquaversal dip of the sedimentary rock indicates the laccolitic character of the igneous mass. At a short distance from the contact the limestone is horizontal and there the result of the intrusive action is recorded by pressure effects on the shaly member of the formation. The nephelite-syenyte appears in the Baril mountains and extends southward more than fifteen miles. It is older than the andesyte which lies to the north of it. Dioryte is found in three rounded bosses enclosed by the andesyte and it too is older than the andesyte by which it is penetrated. There are also numerous dyke rocks younger than these igneous masses, found as intrusions in all of them.

The limestone is Cretaceous, the andesyte and subsequent dykes post-Cretaceous. The author was unable to determine the relations of the nephelite-syenyte and the limestone and makes no statement as to their relative ages.

The remiander of the paper is devoted to the petrography of the igneous rocks. The author distinguishes,

A.—*Granitoid Types.*

1. Nephelite Syenyte. The San José rock is very uniform in character. Four types are described: The Baril type, the Arroyo Grande type, the Mesa Verde type and a basic facies of it. By

calculation of the norm this rock is found to be persalane, of order 6, russare, damachalic viezzenase, and dosodic, viezzenose; which means that the salic minerals preponderate, that the feldspars are dominant over the feldspathoids, that the alkalies are dominant over lime and soda over potassa.

2. Dioryte. The two principal areas are near San José and the rock is a typical dioryte.

B.—*Porphyritic Type.*

1. Andesyte. The laccolitic mass is exposed for twelve square miles in the centre of which is situated the town of San José. Two types are distinguished and an analysis of one is given and is shown to be a laurvikose in which the salic constituents and the feldspars preponderate; in which the alkalies are dominant over lime and soda over potassa.

2. Dacyte. This is a more siliceous facies of the andesyte found in the hills south of San José of which two types are distinquished.

3. Basalt. It is a bluish black lava extending along the Arrayo Grande for four or five miles.

C.—*Dyke Rocks.*

The dyke rocks of the region about San José are separated into two groups striking at right angles to each other. Acid tinguaytes strike east and west and a basic series of camptonytes vogesytes and limburgytes strike north and south. The tinguaytes are divided into a porphyritic type and an aphanitic tinguayte bearing analcite.

A discussion of the chemical relations of the San José rocks closes the paper.

There is a wide range between the acid and the basic rocks but the tabulated analyses show a definite sequence the nature of which is indicated by the writer.

The paper is illustrated by a geological map of the San José district, by ten photomicrographs of the igneous types and five views of the mountains surrounding San José. A. J.

The Geology of the Cerrillos Hills, New Mexico. By DOUGLAS WILSON JOHNSON. (Contributions from the Geological Department of Columbia University, vol. x, No. 90.)

This paper is a discussion of the igneous hills in the region of Cerrillos, New Mexico, with a detailed description of the surrounding sedimentary formations. The subject is treated in three parts: Part I. is concerned with the stratigraphy, physiography, geologic history and economic products of the district; Part II. contains a description of the palaeontology of the sedimentary formations; Part III. gives an account of the petrography of the igneous formations.

The Cerrillos hills are laccoliths of hornblende-and augite-andesyte which have been intruded in Cretaceous sediments. The over-arching sediments have since been removed by erosion, leaving the igneous core exposed. Mr. Johnson is the first to suggest a laccolitic origin for these hills which have been considered by earlier geologists to be remnants of great dykes or of old volcanoes in which the core has been partially eroded. He asserts as proof of his conclusion the following facts:

1. The absence of eruptive fragments in the associated strata.
2. The compact crystalline texture of the rock which is hard, dense and in places almost granitoid.
3. The dip of the strata away from the hills showing tilting subsequent to deposition.
4. Intrusive tongues of lava in the adjacent beds.
5. Metamorphism in the beds resting on the laccoliths.
6. The quaquaversal dip around the laccoliths.
7. The relation of the intrusive sheets accompanying the laccoliths which are thicker near the uplift and thinner and less steeply inclined at a distance from it.
8. The evidence of annular drainage as shown in the San Marcos Arroyo.

The Mesozoic sediments surrounding the laccoliths cover a succession of deposits extending from the lowest beds, found at the base of the Galisteo monocline and presumably of Jura-Trias age through the Laramie deposits of Galisteo red sandstone. During the Fox Hills period there was a deposition of lignite which has been altered subsequently to bituminous and anthracite coal by the metamorphic action of the intrusive sills. There followed a long erosion interval during which the andesyte was intruded and the region peneplained. The deposition of the Santa Fe marls began and continued from the Loup Fork stage until recent times. These were supposed to have originated in one of the great lakes that were so numerous in the western interior during Tertiary times. The author however, suggests that these marls are of alluvial rather than of lacustrine origin and advances in support of this theory the following proofs:

1. The variation in texture and composition of the beds in vertical section.
2. The presence of beds of conglomerate.
3. The sudden variations in thickness and extent of the component beds.
4. The presence of erosion unconformities.
5. The development of cross bedding.
6. The presence of land fauna.
7. The absence of a lake schoreline.

To Mr. Johnson the above facts seem conclusive. While these

conditions would occur in the case of fluviatile deposits and may be considered as evidence pointing to an alluvial origin they are hardly to be considered as absolute proof of such an origin.

In water of constantly varying depth there would be variation in the texture and composition of the beds. Because of an alternate deepening and shallowing of the water we may get a succession of gravel, marls and gravel. A possible elevation in one part of the lake accompanied by depression in another part would cause changes in the thickness and extent of the component beds and might produce an erosion line. Ripple marks have been in some cases preserved to the distance of a mile or more from the shore as in the case of Great Salt lake. Cross bedding in lakes due to the action of counter currents has been observed and wind currents have been effective in producing this phenomenon. Subangular conglomerate may be formed from pebbles which have been transportd a short distance and quickly cemented by calcium carbonate deposited from the saturated water. If we assume that the Cerrillos peaks emerged from a lake as islands, the material for the conglomerate might be furnished by the erosion of these islands, and alluvial deposits from the mountain streams emptying into the lake would account for the presence of the alluvial fans at the base of the present mountains.

The economic products of this region are:

1. The anthracite and bituminous coal of the Madrid field.

2. The turquoise deposits of Turquoise hill. These are found as veins and nodules throughout the augite andesyte and have been altered from the country rock by heated solutions and vapors rising along lines of fracture.

In Part II Mr. Johnson gives a detailed account of the palaeontology of the region describing with great accuracy the fossils collected from nine different sections. These descriptions are illustrated by a fine series of plates which add greatly to the interest of the book. The whole article shows evidence of the most careful and accurate work.

In Part III five series of rocks are described:

1. The mica-andesyte forming sheets interstratified with shale.

2. The eruptive breccias of the Galisteo group.

3. The hornblende-andesyte forming the older and smaller laccoliths.

4. The augite-andesyte, which is the most abundant rock of the Cerrillos district and which forms the main part of the laccolitic uplift.

5. The olivine basalt which forms the lava flow of Mt. Calvary and occurs in radial dykes as the basic limburgyte.

Mr. Johnson has classified the Cerrillos rock under the chemico-

mineralogical system of classification and has given the equations for the respective class order, rang and grad, thereby making the nomenclature clearly intelligible to those who are not as yet completely familiar with the new scheme.

His treatment of the Cerrillos district is clear and logical, written in a very interesting manner and complete in all respects. In addition to the palaeontological plates the book is illustrated by a large map of the region, accompanied by sections, by numerous full page photographs, by various half page diagrams and plates, and by a series of photo-micrographs. E. F. B.

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PERSONAL AND SCIENTIFIC NEWS.

DR. J. MACKINTOSH BELL instructor in geology at Harvard University, a nephew of Dr. Robert Bell, acting director of the Goelogical Survey of Canada, has been appointed government geologist of New Zealand, to succeed Sir James Hector. *Science.*)

DR. HENRY MONTGOMERY has been appointed curator of the museum at the University of Toronto, Ont.

DR. GEORGE P. MORRILL was elected president of the Geological Society of Washington and Waldemar Lindgren and A. H. Brooks vice presidents, at the twelfth annual meeting of the society.

AWARDS IN THE DEPARTMENT OF MINES AND METALLURGY, LOUISIANA PURCHASE EXPOSITION, 1904

Below is given a list of State and Government geological survey awards granted, based on their work and their exhibits at the St. Louis Exposition. This is the first time in the history of expositions that the work of the geological surveys received adequate recognition. The recognition received at this Exposition was doubtless due in part to the fact that on the Jury of Awards there were many able geologists and mining engineers representing the United States and other countries, and partly to the fact that the Chief of the Department of Mines of the Exposition was himself a Fellow of the Geological Society of America and a State Geologist.

Grand Prizes to the Following:

United States Geological Survey, Washington.
British Geological Survey, London.
Prussian Geological Survey, Berlin.
Austrian Geological Survey, Vienna.
Swiss Geological Survey, Zurich.
Portuguese Geological Survey, Lisbon.
New York Paleontological Survey, Albany.
Geological Survey of Japan.
Geological Survey of Canada.

Gold Medals to the Following:

Pennsylvania Geological Survey, Harrisburg.
N. H. Winchell, Minneapolis, Minn.
Geological Survey Publications, Minnesota.
Ohio Geological Survey, Columbus.
Geological Survey of New South Wales, Sydney, Ont.
Geological Survey of Alabama, University, Ala.
California State Mining Bureau, San Francisco, Cal.
New York State Museum, Albany. (In Geology).
Geological Survey of New Jersey, Trenton, N. J.
Maryland Geological Survey, Baltimore, Md.
Geological Survey of Missouri, Rolla, Mo.
Geological Survey of West Virginia, Morgantown, West Va.
Geological Survey of Indiana, Indianapolis.
Geological Survey of Georgia, Atlanta, Ga.
Iowa Geological Survey, Des Moines, Iowa.
Wisconsin Geological Survey, Madison, Wis.
John C. Branner, Stanford, Cal.
Publications of the Arkansas Geological Survey.
Kentucky Geological Survey, Frankfort.
Michigan Geological Survey, Lansing, Mich.

THE GEOGRAPHIC SOCIETY OF CHICAGO held a meeting on December 10th, at which the following brief addresses were given: Eliot Blackwelder, "Tai Shan—the Holy Mountain of Shantung;" W. W. Atwood, "An Ascent of the Enchanted Mesa;" R. E. Blount, "A Field Trip in the Harz;" Zonia Baber, "The Transcontinental Trip of the Eighth International Geographic Congress;" Mabel Sykes, "A Trip to Vancouver."

UNITED STATES GEOLOGICAL SURVEY.

Among the recently issued publications of the Survey are the following:

"The petrography and geology of the igneous rocks of the Highwood mountains, Montana," by L. V. Pirsson; Bulletin No. 237.

"The water powers of Texas," by T. C. Taylor; Water Supply and Irrigation Paper No. 105.

"The Delavan lobe of the lake Michigan glacier of the Wisconsin stage of glaciation and associated phenomena," by W. C. Alden; Professional Paper No. 34.

"The Latrobe (Pa.) Folio," by M. R. Campbell; Geologic Folio No. 110.

"A general reconnaissance across the Cascade range near the forty-ninth parallel," by G. O. Smith and F. C. Calkins; Bulletin No. 235.

"Contributions to Devonian paleontology, 1903," by H. S. Williams and E. M. Kindle; Bulletin No. 244.

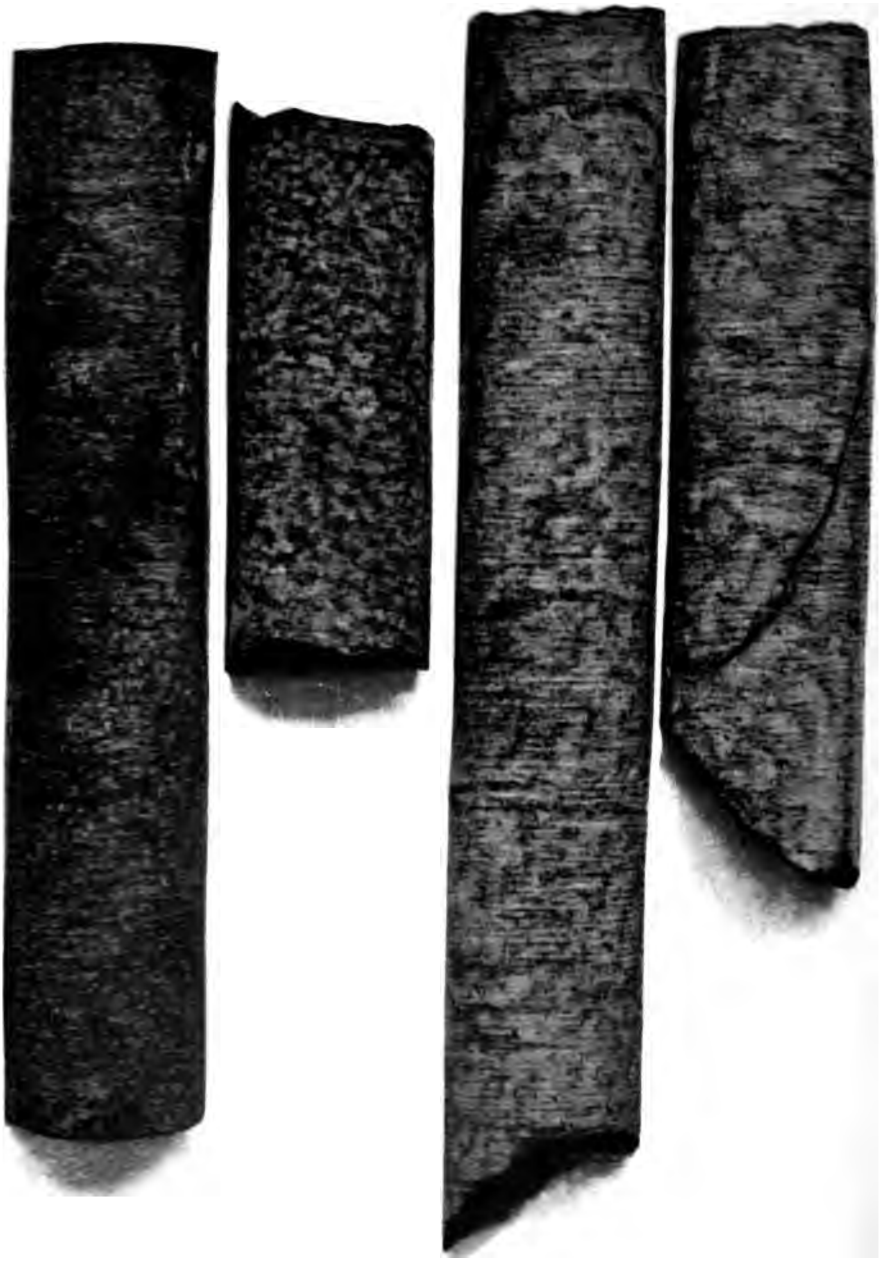
"The twenty-fifth annual report of the Director of the United States Geological Survey." This report includes an account of the work of the survey from July, 1903, to July, 1904.

NEW YORK ACADEMY OF SCIENCES. Nov. 21, 1904, Prof. J. J. Stevenson read a paper upon "The Island of Spitzbergen and its Coal," illustrated by lantern slides. The speaker described briefly the coast of northern Norway and its geology and referred in some detail to Bergen, Hammerfest and other cities. The coal beds are of Jurassic age and the coal is peculiar in that it partakes of the characters of the lignites as well as of the true coals.

Prof. J. F. Kemp presented an abstract of a paper on The Titaniferous Magnetite in Wyoming. The magnetite occurs in two places, fifteen and twenty miles north of Laramie, Wyoming, the former and smaller occurrence being the Shanton ranch, the latter and larger being on Chugwater creek. Both are in wall rock of anorthosyte which is practically indistinguishable from anorthosyte occurring in the Adirondacks. The ores range from 20 per cent to 40 per cent TiO^2. Thin sections show that they contain green spinels and one slide presents much olivine. They can be most reasonably explained as intrusive dikes. In this view the speaker agreed with Waldemar Lindgren who has published a brief note regarding them.

A special meeting of the Section of Geology and Mineralogy was held December 2, when a lecture was given by Prof. Albrecht Penck, of the Imperial University at Vienna, who is an honorary member of the academy.

The speaker discussed "The Glacial Surface Features of the Alps," and gave a brief summary of some of the results of the twenty years of masterly work which has been done by him and under his direction in the Tyrol. Professor Penck discussed in popular language the nature of the valleys of the Alps and showed by means of lantern slides and a diagram how the glaciers have widened and deepened portions of their rock basins and produced lakes. A vote of thanks was passed to the distinguished guest of the evening.



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APPROXIMATE DISTANCE FROM MARGIN, IN FEET:

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LUSTER-MOTTLING IN DRILL-CORES OF OPHITES.

THE
AMERICAN GEOLOGIST.

VOL. XXXV. FEBRUARY, 1905. No. 2.

THE COARSENESS OF IGNEOUS ROCKS AND ITS MEANING.

ALFRED C. LANE, Lansing, Mich.

PLATE IV.

For some time* and in a series of papers I have been interested in studying the grain of rocks, its variation in coarseness and the inferences that may be drawn therefrom. Though I began studying it by noticing the dimensions of cross sections of certain crystals in thin sections it has become evident to me that in many cases microscopic work and thin sections are not necessary nor even definite numerical results (though always advisable) in order to draw inferences of interest. I wish therefore in this article to give briefly without either the mathematical foundations or the exact mathematical limitations, some of the results of my studies in such shape as to attract the attention and interest of geologists generally to the value of inferences from the coarseness of grain. I should only premise, that if any one finds that the inferences here drawn do not agree with facts known to him of which he is absolutely sure, it is quite as likely that I have left out, in restating the facts without mathematics, some essential limiting factor as that the general theory is seriously defective. There is however one presupposition I make, which is not strictly true, variations from which may cause great variations in the results. That is, that the whole mass of the igneous rock when it was

* Part 1, volume vi, Reports Geological Survey of Michigan; *Bull Geol. Soc. Am.* pp. 369-406; viii, pp. 403-407; Annual Reports, for 1903 and 1904, Mich. Geol. Surv. *Am. Jour. of Science*, Vol. xiv, Nov., 1902, p. 393.
The plate herewith given is prepared for the Annual Report for 1904.

poured forth, or squeezed in, was under uniform conditions of liquefaction, temperature, pressure and absorbed mineralizing gases. We shall, at the close, consider some modifications of the phenomena which may be assigned to non-uniform conditions.

One important condition of the coarseness of a given mineral is the rapidity with which it forms. The slower the formation the coarser the grain. This in turn will obviously depend in some measure upon the ease with which its environment (country rock, air or water) can absorb the liquefying factors (heat, or mineralizing gases, etc.) Thus a lava poured forth beneath the ocean may be expected to lose heat faster than one intruded into dry sand. We try to allow for these factors by assuming various widths of contact zones.

The coarseness of grain of a rock is not a mathematical conception. We may better speak of the coarseness of grain of an individual constituent, the feldspar or augite or quartz of a rock. The general impression of the coarseness of grain of the rock as a whole may be due to the composite effect of one or two or three of the constituent minerals. Usually the grain of the feldspar is an important factor. In the plate of drill cores (iv.) the mottling is, however, due to the ophitic augites, which on fresh fracture give a luster-mottled effect. At times also two or more minerals, may vary in the same way, and we may speak of the grain becoming coarser for all of them and so for the rock which they make up.

Now in our mathematical discussion we call the conditions of consolidation (u), those of the igneous rock as it is poured forth or thrust in (u_A) and those of the country rock zero (o).

(A.) If the conditions of consolidation are nearer the former (u_A) than the latter, the grain at the margin is finer, theoretically indefinitely fine. The igneous rock will have a glassy or aphanitic "saalband," selvage or wall. This we know is the customary thing for common trap dikes. The grain will increase at first from the margin at a uniform rate, not dependent on the thickness of the country rock nor of the contact zone.

If the contact zone is a broad one not cooling rapidly, but letting the plane of contact remain for some time in conditions just half way between those the country rock and the igneous rock had at the beginning (o) and (a-A), the grain will continue to increase though not at a uniform rate, until it may even be a good deal coarser than farther from the margin. This belt of coarser grain not at, but parallel to, the margin will be pronounced only in rather exceptional conditions, when the contact zone is quite broad, and the temperature of consolidation only a little nearer the temperature of injection than that of the country rock.

After a short time if the contact zone is a narrow one, a longer time if it is broad, the contact zone will be heated up so that the igneous rock will cool as though it were the outside of the contact zone which was its margin held at a fixed temperature, and if the contact zone is very narrow, as it generally seems to be in effusive rocks, the grain increases once more uniformly. It will do this more especially if the temperature of consolidation is pretty close to that of the molten rock when it came to rest. This seems frequently to be the case with effusive basic lavas which flowed on and on and stirred themselves up until the earlier crystals began to form while the lava was still in motion. Then it began to stiffen, and at this time and temperature it was on the verge of consolidation throughout.

For instance the most common type of Keweenawan trap is an ophyte mainly composed of augite and labradorite with some iron oxides and olivine in chemical composition an auvergnose close to a hessose, with about 47 per cent SiO^2, 10 per cent CaO and 3 per cent alkalies. The type is the great ridge known as the "greenstone." Such flows continued to spread until the olivine and probably also the feldspar had begun to form. We find in them that the augite is the last formed mineral, and that its grains enclose the tablets of feldspar, but crowd ahead of them the other components so far as possible. These augite patches attain a perceptible size as will be seen by plate IV in four to ten feet from the margin. This corresponds to the first rate of increase. Thereafter the increase of size of patches is less rapid but fairly uniform and continuous, something

like one millimeter in breadth of patch, diameter of augite grain, for every sixteen feet distance from the margin. Some valuable application can be made of these facts.

(1) If a sample appears to be unusually fine grained for its distance from the margin of the flow it is often found that it is more feldspathic than the normal ophytes (andose, i. e. "ashbed diabase, i. e. porphyritic melaphyre, or something still more felsitic.)

(2) The direction in which the mottles (grain) are getting finer is probably that of the nearest amygdaloid,* and the coarseness of the mottles enables one to infer about how far off (or ahead in diamond drilling) it may be expected if slips do not intervene.

(3) As Dr. Hubbard suggests, if a flow appears by chemical or petrographic analysis to be a normal ophyte but when cut by a drill hole the grain does not increase at the normal rate it may be possible to infer the dip. In a vertical shaft or drill hole, the apparent rate would be the real rate of 16 feet per millimeter divided by the cosine of the dip. But the difficulty of determining the rate of increase of grain accurately, the liability of drill holes to veer, and the possibility of exceptional temperatures in the flow are all factors that should lead to extreme caution in the application of this method. The dip thus obtained should be taken as a suggestion. I have however used it with better success than I expected.

(4) Sudden variations in grain may serve to call attention to faults and slips.

(5) Intrusive dikes behave quite differently.

(B.) If the conditions of consolidation are nearer those of the country rock than those the rock had at the time of intrusion and the beginning of cooling, it will be coarser at the margin than at a little distance therefrom. If the contact zone is very narrow the zone of decrease of grain will be very small, and from thence in the grain will be as though the consolidation was from the outer margin of the contact zone kept at a fixed temperature. But if the contact zone is broad there will be a gradual decrease of grain to the zone of uniform grain of which we shall presently speak, the extra

* The porous bubbly top of a flow.

coarseness of the margin being pronounced only as the conditions of its consolidation approach being balanced just half way between those of the country rock and initially injected magma.

(C) If the temperature and conditions at which the molten rock comes to rest are not very near or within the range of conditions of consolidation there will be back from the margin and near to the center a zone of uniform grain. This will not be all formed at the same time, but the molten rock will be cooling down at the same rate when it gets down to the same temperature. This is a result of very wide application. The proportion of this zone of uniform width depends on the relations of the three temperatures, those of beginning of consolidation and of the country rock. The nearer the latter is to that of consolidation the broader the belt of uniform grain. The broader the contact zone the more extensive the belt of uniform grain, as might be expected, for the broad contact zone means one that absorbs relatively little heat and will make the difference between the margin and center in conditions less.

The formula for the grain through this center belt is so simple that we shall venture to give it as:

$E =$ [illegible]

Which being interpreted is as follows:

The coarseness of grain (E) in the belt of uniform grain is proportional to the ease of crystallization and the molecular abundance of the mineral concerned (k), and to the size of the mass of rock whose temperature varies considered as a sheet of indefinite extent and thickness (c), and inversely proportional to the square root of the diffusivity (a^2), and the difference between the temperature (and other conditions) of consolidation and those prevailing in the country rock (u).

It will be noticed that in this formula the initial temperature and conditions of the molten rock do not enter, and play no role. These must be studied at or near the contact.

We have said that this central zone of uniform grain is not all formed at the same time. Now if in what would otherwise be such a contact zone there is a concentration

by gravitative settling or any other method of the more soluble and less quickly crystallizable part, we may have a coarser grain due to the practical decrease of (u) the temperature and conditions of consolidation, or the increase of (k) the molecular abundance of some particular mineral.

Again at the moment of injection or effusion a certain width of the molten rock may crystallize, and in that case consolidate as though the country rock and the margin had the actual temperatures of injection. But within this stiffened rind a flow may go on before final cessation of motion. The consolidation just within the rind will be abnormally slow owing to the fresh accessions of heat, and when the rock finally comes to rest it will start with the heated rind for a country rock. Crystals of minerals except those which determine the stiffening of the molten rock will be formed as it pushes along in and along side the rind in the belt whose temperature is lowered to their range of formation. They will be the porphyritic crystals of the rhyocrystal (formed floating in transit) type, and may of course be swept by currents into the middle of the molten stream and even remelted, tending to lower the temperature of the stream as a whole. The net result of considering flowage appears to be that probably in considering the grain at the center a little less range of conditions of temperature (uo) should be assumed than for the margin.

Now for some more applications. The deeper seated rocks, batholiths and intrusives, are likely to have (1) hotter contact zones; (2) owing to the retention of mineralizers under pressure, lower temperatures of consolidation, or more broadly conditions of consolidation more like those prevailing in the rocks in which they are injected; (3) perhaps higher initial or injection temperatures; (4) broader contact zones.

The zone of uniform grain is therefore probably much broader, and coarser grain at the margin is more likely to occur. If there is a zone of uniform grain it is likely to be coarser than a similar zone in an otherwise similar effusive, but it is not necessarily coarser than the grain of the effu-

sive, if that is formed at an early stage and increases continuously from the center.

Extra coarse grain of intrusives like pegmatytes, may point to a country rock near fusion-solution, or to such an accumulation of mineralizers as to bring their consolidation-crystallization point down close to that of the country rock, which amounts to the same thing.

Fine grained rocks of uniform grain like aplytes seem to point to the following conditions: (1) small dimensions (c); which is generally the case; (2) a considerable difference in condition between the consolidation point and that of the country rock (i. e. u reasonably large); (3) but this difference must nevertheless be less than half the initial difference ([illegible])

Suppose for instance a gabbro magma were at 1400° C. originally and consolidated at 1100° C. By the time the margin and contact zone had cooled down to 800° C. there would be a tendency to shrink which might be relieved by injections of residual magma like the "red rock" (soda granites, granitells), at the center which still remained at 1400°. If this residual magma also consolidated at 1100° C. it might take aplitic form, but if very rich in mineralizers, superheated steam, and so liable to consolidate at lower temperatures, might be indefinitely coarse and pegmatitic. Such in fact appears to me to be the probable conditions for many dike rocks.

Regarding the granites and gneisses called Laurentian and regarded by many as the softened base of the geological column, it is now pretty generally agreed that, as was clearly pointed out by Lawson, they behave in their relation to such formations as the Keewatin exactly like any other igneous intrusive. Moreover their grain is not peculiarly coarse, though (and this has indeed been noted by Rominger and Lawson at least, as well as myself) the feldspar often becomes gradually coarser at the margin, "porphyroidal" or "porphyritic," than farther from the contact. From these facts we may infer that there was a very considerable difference in temperature (conditions of consolidation) between the Keweenawan and the "Laurentian" and also that the country rock was nearer the consolidation point of the feld-

spar than the "Laurentian" granite gneisses, in short that at the time of intrusion the Keewatin was nearer to melting than the "Laurentian" to consolidating. I do not believe that these inferences are consistent with the theory that such granites are a softened formation immediately underlying Huronian, Keewatin or Couchiching. I should rather expect that such softened sediments would cool with a coarseness of grain comparable to that of segregation veins and pegmatytes in so far as the same was not broken up by shearing and flowage.

Whether I am right in this particular point, however, in general or not, and of course I can only speak with any degree of assurance for the few contacts I have personally examined, it seems to me that a careful study of the variation of grain will assuredly throw light on this difficult problems as well as others.

Lansing, Jan.5, 1905.

GERARD TROOST.*

By L. C. Glenn, Nashville, Tenn.

PORTRAIT-PLATE V.

Gerard Troost, a pupil and friend of Hauy and Werner, one of the founders and the first president of the Academy of Natural Sciences of Philadelphia, professor of geology and chemistry in the University of Nashville, and first state geologist of Tennessee, was born at Bois-le-Duc, Holland, March 15, 1776, and died in Nashville, Tenn., August 14, 1850. Though his parents had but limited means, he was educated at the University of Leyden, where he received the degree of Doctor of Medicine, and at the University of Amsterdam, where in 1801 he received the degree of master in pharmacy. Much of his time was devoted to chemistry and natural history and especially to the then infant sciences of geology and mineralogy.

* The writer has drawn quite freely on Dr. Philip Lindsley's oration on the life and character of Dr. Troost. Acknowledgements for information and assistance in various ways are also gratefully made to Ex-Gov. James D. Porter, and Mr. Jno. M. Bass, president and secretary, respectively, of the University of Nashville; to Prof. Charles Schuchert now of Yale; to Mr. Chas. J. Fox of the Academy of Natural Sciences of Philadelphia; to Mr. Lewis Stein of Spring Hill, Ala.; and to Dr. James M. Safford, of Dallas, Tex.

Between 1801 and 1807, Dr. Troost practiced as a pharmacist, both at Amsterdam and at the Hague, and served in the army first as a private soldier and later as an officer of health of the first class and during his service was wounded in the forehead and in the thigh. The work of a pharmacist, it should be remembered, was that of a chemist manufacturing medicinal preparations and required a much fuller and more accurate knowledge of chemistry, botany and zoology than would be necessary for the mere compounding of prescriptions.

He had by this time attracted the attention of Louis Napoleon, king of Holland, and was sent by him to Paris to continue his scientific studies. His passport bears date of July 1, 1807. There he became a pupil and companion of Hauy, the celebrated crystallographer and mineralogist, and gained that knowledge of and fondness for mineralogy and crystallography which he always afterward manifested and which led his associates in America to wonder at his remarkable fidelity in remembering the exact angles of known crystals of minerals and his readily distinguishing rare and remarkable forms. While there he translated into Dutch Humboldt's "Aspects of Nature" and established thereby a lifelong friendship with the author. He soon became at home in Paris, familiar with its language and acquainted with its leaders of scientific thought. At some time between 1807 and 1809, Troost traveled widely in France, Italy, Switzerland and Germany under commission from the king of Holland collecting, by purchase, for him a large and valuable cabinet of minerals. It was most probably during his travels for this purpose in Germany that he sat under Werner's instruction and became his companion in excursions around Freiberg. Troost often referred in his lectures to incidents of his travels during this period and frequently spoke of Werner in warm terms of appreciation. No reference was ever made by him to his having traveled in Egypt and no authentication of the statement that he visited that country in a scientific capacity for the French government is obtainable. It seems highly improbable that such a trip was ever made.

About the close of 1809 Dr. Troost was appointed by

the king of Holland a member of a scientific commission to accompany a naval expedition to Java. The English blockade prevented the sailing of the Dutch fleet, and the attempt was made by Dr. Troost to reach the United States and sail thence to the East Indies under our flag. He sailed from a German port in an American vessel bound for the United States, but was captured by a French privateer and carried as a prisoner to Dunkirk, where he was confined until his true name and character were learned.. He was then released, and proceeded to Paris. There he was elected a corresponding member of the Museum of Natural History of France, his diploma being dated March 21, 1810. He had secured, however, on March 5, a passport in Paris permitting him to sail on an American ship from Rochelle to Philadelphia, and shortly afterwards departed for America.

On July 1, 1810, Louis Napoleon abdicated the crown of Holland, and on July 10 that country was incorporated with the French empire. In the following year Java was surrendered to the British.

Under these circumstances, Dr. Troost abandoned the expedition to the East Indies and resolved to remain in this country and become an American citizen. He settled in Philadelphia and soon established there a laboratory for manufacturing drugs and chemical preparations.

In 1812, Dr. Troost became one of the founders of the Academy of Natural Sciences in Philadelphia and was elected its first president, a position he held until 1817, when he resigned and was succeeded by Thomas Say. Soon after the founding of the Academy, when the members made donations to form the nucleus of a museum, Dr. Troost presented some artificial crystals he had prepared. Later, he gave collections of minerals from Pennsylvania and from Maryland, and a number of other things of scientific interest and value. A collection of minerals purchased from Dr. Seybert came into the possession of the Academy on August 15, 1812, and soon after this Dr. Troost delivered a course of lectures on mineralogy before the Academy. This was perhaps his first formal work as a lecturer or teacher.

In 1811, he became associated with others in the manufacture of alum from the pyritic and lignitic Cretaceous clays

found at cape Sable on the Magothy river in Maryland, thus establishing the first alum manufactory in the United States. He later removed there from Philadelphia, but after a few years the failure of the proprietors involved him in heavy financial loss, the works were closed, and he returned to Philadelphia. In 1821 he was appointed professor of mineralogy in the Philadelphia museum and delivered a course of public lectures on the subject. At about the same time he was also appointed first professor of chemistry in the Philadelphia College of Pharmacy. He delivered one course of lectures and resigned the following year. During this last residence in Philadelphia he made frequent geological excursions into the region around Philadelphia, to the zinc mines of Sussex County, N. J., and to Orange County, N. Y., and elsewhere, being accompanied at times by Maclure, Say, Lesueur, and Jackson.

Between 1821 and 1825 he made for the Philadelphia Society for the Promoting of Agriculture a geological survey of the environs of Philadelphia.

In 1825, along with Maclure, Say, Lesueur and others, he removed to New Harmony, Indiana, and aided in forming the communistic colony there under the auspices of Robert Owen. He soon became dissatisfied with the impracticable schemes and peculiar social arrangements of Owen, and removed with his family and scientific collections to Nashville, Tenn. During his stay at New Harmony, however, he made a trip into southeast Missouri along with Lesueur to the lead and zinc mines of that state. He called the attention of the miners there to the true nature of the calamine ore, all of which they had previously thrown away as worthless.

It is very probable that Dr. Troost was induced to move to Nashville by Dr. Philip Lindsley, the president of the University of Nashville. On January 11, 1828, he advertised in one of the daily papers that his museum, the work of twenty years collecting, is now open to the public, and mentions that among its contents are over 400 species of birds from the island of Java alone,—one of the results, no doubt, of the interest in Java aroused by his attempted expedition to that island. On February 9, 1828, he was elected professor of geology and mineralogy in the University of

Nashville. Shortly afterward chemistry and natural history were added to his chair. He retained this position until his death.

Dr. Troost soon began to make geological expeditions over the state of Tennessee, and in an address delivered before the legislature on October 19, 1831, we find him already well informed regarding many of the state's natural resources. He was persuaded to communicate his findings to the legislature that steps might be taken for their further development. As a consequence, a geological survey was authorized and he was appointed geologist, mineralogist and assayer for the State on December 21, 1831. This position he held by biennial reappointment until it was abolished by the legislature February 4, 1850. His salary from the college was $1,000 per year and from the State $250 for each of the first two years and thereafter $500 per year, but out of the latter he paid his traveling and other field expenses. Well might the Board of Trustees of the University of Nashville vote, as it did, to defray his funeral expenses, and well might the State of Tennessee resolve, as it has not yet done, to place a suitable stone over his unmarked resting place.

Physically, Dr. Troost was short and thick-set with a distinctly German, but pleasant and benevolent physiognomy. His dress was somewhat careless, and in his old age his hair was white. His manners were kindly and courteous and marked by unassuming simplicity. In his travels over the state he readily won the friendship and regard of all classes of people with whom he came in contact. In his speech he retained enough of his native Dutch accent to render his foreign birth apparent.

As a college professor, he seemed always provided with a storehouse of information and apt illustration and would present it in a way that could not fail to interest. He would sometimes start to examine on a subject and, on some casual suggestion, would branch off into a lecture instead that would be, as one of his students describes it, a perfect revelation. Many of his students regarded their contact with him as the most valuable experience of their lives. Though usually affable and benign, he could on occasion be blunt of speech and with aroused ire administer stern rebuke. Es-

pecially indignant did he become at any species of scientific quackery or ignorant presumption.

Though a hard student, he was not a recluse but was a polished man of the world. He had traveled and seen much in the old world and had lived among the *savants* of Paris and mingled on easy and equal terms with the most polished circles of the city. He had been long familiar with the tone and atmosphere of fashionable society and never lost his fondness for the endearments of social life. The best of husbands and fathers, his private life was a model of domestic happiness. As a religionist, he belonged to the denomination known in Holland as Remonstrants and elsewhere as Armenians.

Dr. Troost was a scholar as well as a savant and philosopher. He was well acquainted with classic and general literature and was master of several languages, ancient and modern, and perhaps there were but few works in Dutch, German, French, or English on any branch of natural science that he had not read or examined. Numerous references in his writings show that he kept up with the times and purchased the scientific works of his day in which he was interested as fast as they appeared. His library is described as large and judiciously selected and abounding not only in the standard works on science in the several languages above but also in valuable engravings, prints, and lithographs. So far it has been impossible to obtain any trace of his library to-day. It was not purchased by the city of Louisville, Ky., as has been reported. One supposition is that while stored in the basement of the capitol here the boxes were broken open and it was scattered or stolen piecemeal. Another is that along with much other material, it was carted out by the Federal troops when they took Nashville during the civil war and burned in order to make room for a mess hall in the basement of the capitol. Almost no private letters or other of his personal effects are left. The manuscripts of one or two of his geological reports are on file in the office of the secretary of state and the state library has one or two volumes he once possessed.

He was a member, active, corresponding or honorary, of a large number of scientific societies in America and in Eu-

rope. The title to the address already mentioned as delivered before the legislature of Tennessee as a plea for establishing a state geological survey names a number of societies to which he belonged and in the appended bibliography this title is given in full in order to preserve this list. To it the writer can add that he was also a member of the Geological Society of Pennsylvania, the Geological Society of France and the Geological Society of Germany. In addition to membership in scientific societies, he was a Mason of high degree.

It is difficult to form a just estimate at this day of Dr. Troost's scientific work, largely because of the impossibility of realizing fully the conditions under which he labored. There was very little scientific work being done anywhere in America in 1811, and very little in the region west of the Appalachian mountains between 1825 and 1850. His studies with Hauy and his early occupation in America as a manufacturing chemist made him a skillful crystallographer and mineralogist and his earlier scientific investigations and published papers evinced his great interest in these subjects. Although later in life his attention was largely turned to natural history, paleontology and geology, it is probable that he was always strongest as a mineralogist, though his monograph on the crinoids of Tennessee, presently to be noticed, would if published, have added materially to his prominence in paleontology.

His interest in natural history which had already led him to the possession in 1828 of over 400 species of mounted birds from the island of Java alone, increased in his later life, and in his excursions over the state he collected natural history specimens as eagerly as geological ones. He became particularly interested in reptilian life, and snakes especially became a hobby with him. He usually had several pet ones around his room and frequently carried one or more in his pockets. Students who took him a rare specimen of a snake won their way at once into his good graces. Featherstonhaugh tells of Dr. Troost's traveling on top of a stage coach with two large rattlesnakes in a basket when, the cover coming unfastened, their peering heads caused a precipitate scattering of driver and passengers on top and with-

G. Troost
Geologist of the State

in. Not in the least disturbed, Troost removed his coat, tied it over the basket and sought to quiet the fears of his fellow passengers by the advice, "Gendlemen, only don't let dese poor dings pite you unt dey won't hoort you."

He was also interested in ethnology and found in Tennessee a most excellent field in which to collect and study the relics of the mound-builders and other aborigines, specimens of whose handiwork are found so abundantly and often in such rare and interesting forms in this state.

Some of the rocks of Tennessee are highly fossiliferous and in his geological work, Dr. Troost had abundant opportunity for collecting paleontological material. He published a number of articles describing the new species found, and lists and descriptions of fossils were added to several of his reports as state geologist, as notably the fifth report, which is often referred to as "Troost's list."

Shortly after becoming state geologist he projected a translation of Goldfuss' *Petrefactenkunde* and arranged to use the original plates, designing to add, as an appendix, descriptions and plates of Tennessee fossils. Responses to the subscriptions invited were too few to justify the undertaking and, the State having declined to aid, the proposed translation was reluctantly abandoned.

Dr. Troost became especially interested in the crinoids of Tennessee and finished only a short time before his death a monograph describing and figuring 107 species of them. This was submitted to the State as an appendix to his tenth report but its publication by the State was declined. It was then submitted to the Smithsonian Institution, which accepted it and referred it for revision to a committee consisting of Prof. Louis Agassiz and Prof. James Hall. The manuscript was received by the Smithsonian Institution July 18, 1850, and was carried to Albany by Dr. James M. Safford, along with the specimens and placed in the hands of professor Hall, who sent them to professor Agassiz for revision. The subsequent unfortunate history of this work of Dr. Troost may be best given by quoting from professor Charles Schuchert's paper "On Siluric and Devonic Cystidea and Camarocrinus."*

* Smithsonian Misc. Coll., Quart. Issue, vol. 2, pp. 220 and 221, 1904.

"After the paper had remained unrevised by Agassiz for five years, the manuscript was turned over to Hall and on the cover the latter wrote, 'received from Prof. Agassiz in Cambridge, August 23d, 1855, James Hall.' Many years later Meek made enquiries at the Smithsonian Institution regarding this work and received the following reply:

"Washington, D. C., July 21, 1868.

"My Dear Mr. Meek:

"I can tell you nothing about present condition of Troost's paper or what Prof. Hall has done or will do with it. Nor does Prof. Henry remember anything of any plan or arrangement. We have published nothing and know of no publication.

Sincerely yours,

F. B. Meek, S. F. BAIRD.

Springfield, Ill."

"Troost's manuscript and fossils remained in professor Hall's possession for more than forty years and the matter was lost sight of by the Smithsonian authorities. After professor Hall's death, the writer called the attention of the National Museum authorities to Troost's manuscript and fossils still remaining at Albany, and finally in the month of November, 1898, the acting administrator of the Hall estate returned to Washington 294 specimens and the manuscript and drawings for 107 species. The specimens for 17 species are still missing. In the Annual Report of the National Museum for 1899, p. 39, is the following statement:

"As a matter of historical interest, it may be noted that the Troost collection of crinoidea, which, together with the manuscript describing them and the drawings for 107 species, was sent by the Smithsonian Institution to professor James Hall in 1853, was returned last November by the administrator of the Hall estate."

"This work with very little revision could well have been published in 1850 and most of Troost's species would have been saved to him. However, as it was and still is the custom of the Smithsonian Institution to refer all manuscripts submitted for publication to a committee of specialists for advice, it is very unfortunate that the work was thus allowed to fall into neglect. Since 1850 most of the species have been described, mainly by Hall, but what are left of new species will in the near future be revived. The blastoids have recently been reworked by Hambach (Trans. St. Louis Acad. Sci., 1904), and the only cystid is described in this paper."

This more than mere neglect of James Hall in keeping Troost's manuscript and specimens in his possession over forty years while he described from time to time under his own name first one and then another of Troost's species

as they came to his hands from other sources has worked an injustice to Troost that cannot now be remedied. It cannot now be known whether Hall was prompted to act as he did simply by the desire to take for himself the credit of describing the new species or was prompted by some personal feeling toward Troost since the latter, as was well known then, strongly deprecated Hall's custom of giving local names to geological formations and refused to use these names for the same formations as they occurred in Tennessee. The Smithsonian Institution has promised through Prof. Schuchert as above quoted, to render what partial reparation is now possible by the early revision and publication of the memoir.

Dr. Troost's museum was a notable one for its time. Some years before his death he disposed of his collections in comparative anatomy and sent to Europe his material in zoology and botany. At his death it contained 13,582 specimens of minerals, 2,851 in paleontology, between 2,000 and 3,000 rocks, shells—not numbered, and many Indian dresses, ornaments, weapons, and relics from mounds. Unsuccessful efforts were made to have it purchased for the University of Nashville, then by the city of Nashville, and later by the State. It was finally sold in 1874 to the trustees of the public library of Kentucky after examination and recommendation by Dr. J. Lawrence Smith and Dr. Yandell. The $20,500 paid for it was raised by five lottery drawings, the "little sin in the matter of the thing" being excused, as the public library paper of Louisville said, by the great good growing out of it. The collection is at present housed in the library's building in Louisville, Ky.

The writer understands that Dr. J. Lawrence Smith later secured the meteorites in the collection from the trustees of the library.

As a geologist, Dr. Troost had done considerable work in the region accessible from Philadelphia while a resident there.

Along with Lesueur he first pointed out to the miners in Missouri the true nature of calamine and discovered the existence of cobalt ore there. He early delimited the coal area of Tennessee and directed attention in his various reports to many of the mineral resources of the state that

were either undiscovered or undeveloped. It is impossible at this late day to determine the extent to which the State has been benefited by his work.

Dr. Troost was the first to call attention to the deposits of marble in east Tennessee whose development has become so important an industry, and if this had been the only result of his work the state would have been amply repaid for all of the expenditures incurred in the survey.

Although Dr. Troost soon obtained a good knowledge of the geology of Tennessee, he never succeeded in unraveling the complicated structure of the eastern part of the state. In his illustrated sections across the state he represented the folded and faulted beds of east Tennessee as a continuous series from the North Carolina line westward, dipping at a uniform, steep angle westward beneath the Cumberland plateau and never reappearing in middle Tennessee as they are known to do, though in his later reports he recognizes the rocks of middle Tennessee as Silurian.

He was wedded to the old European classification and although he at last came to use the terms Cambrian and Silurian instead of grauwacke, he deprecated the day when each state might have its own peculiar set of geological names based on local terms and was hardly willing to admit that there was any merit in the New York system.

The results of Dr. Troost's work as state geologist were embodied in ten reports made to the legislature. Several of these reports were never published and those that were published are rarely found to-day. There is much ignorance concerning certain of them.

The address delivered to the legislature on October 16, 1831, is generally regarded as the first report and is even catalogued as such whereas it was really a plea for the establishment of a survey. The first report was presented at the called session of the legislature in 1832 and read in the House on September 18, 1832,* but failed to be ordered printed. It contained a general account of the more prominent geological features of the state so far as then known to Dr. Troost and a particular description of Davidson county in which Nashville is situated and outlined the extent of the

* House Jour., Called Ses. of 1832, p 10.

coal formations of the state. It may have also included a description of parts of some of the adjacent counties, included in the second report. An extract from this first report may be found in the transactions of the Geological Society of Pennsylvania, vol. 1, pp. 240-243.

The second report was presented at the regular session of the legislature in 1833 and each succeeding report was presented at the biennial sessions which followed until the tenth and last had been made in 1849. The second report embodied the results given in the first report along with those obtained during the second. This report was referred to a committee which recommended that since it was not like the usual legislative document a brief summary prepared by them be published instead. Since the writer has had numerous enquiries for this report* it is presented here, and reads as follows:

"Mr. Nicholson from the select committee on statistics, made a detailed report in writing, which was read at the clerk's table as follows, to-wit:

The committee have examined the report made to this house by the Geologist, and are convinced that it contains valuable information to the citizens of the state. Its length, however, in the opinion of the committee, will prevent such a careful perusal by the members of the legislature as its importance demands, and on that account the committee thought they would best subserve the interests of the State by giving a brief analysis of the contents of the report.

ANALYSIS of the Geological description of Davidson, Williamson and Maury counties, accompanied by a Geological Map, and Sections of Stratification, by Dr. G. Troost, Geologist of the State of Tennessee:

"After having sketched in an interesting preface the labors and the enjoyments of the naturalist who investigates the structure of the crust of the globe he inhabits, and after having examined the first causes which have advanced man to his present state, Dr. Troost describes the astonishing progress which the science of geology has made during the present generation. He says:

"Its principal founders and innovators have not yet all left the stage of this life. In our new and happy country, its votaries are not only vastly increasing, but they find protectors and encouragement from our first and most eminent men. Several of our legislatures, convinced of the utility of geological examinations, have appointed persons to investigate the structure and mineral

* House Jour. for 1833, pp. 303-305.

resources of their respective states; the legislature of Tennessee was among the first that have distinguished themselves as the patrons of this science."

"Before he proceeds to give a regular view of the geology of the counties of Davidson, Williamson and Maury, he gives a general outline of the geology of the greatest portion of the state. From this outline the committee learn that we may count several series or formations of rocks in the state of Tennessee. He considers that part which is beyond the eastern declivity of the Cumberland mountain, as belonging to what geologists term the *first transition* or *gray wacke formation*. The greater part of the Cumberland mountain he considered as belonging to the *coal formations*, of which he has given the extent in the report already made and read to the House. This coal formation rests on a series of strata of *oölitic limestone*. This oölyte series covers the limestone strata which prevail in the three counties mentioned. These limestone strata are covered with a series of agrillaceous and siliceous strata, in which our rich deposits of iron are found, and which again are covered towards the western part of Tennessee with the Thiatyary [sic] formations.

"After having given this precursory view of the geology of the state, Dr. Troost gives a detailed description of the geology of the three counties before mentioned. He describes with much precision, the different strata, their accidental minerals, among which he enumerates several varieties of *plaster-sulphate* of *barytes*, and *strontian* and their metallic deposits. The part of the description, now before the committee, contains only one description of such metallic deposit, viz.: that of a vein of lead, which promises to be advantageous to its proprietor. He is also very particular in describing what he calls the *Sandstone* strata, which covers the limestone. But, as, according to the opinions of the most distinguished geologists, the relative age of the various strata can be determined only from the imbedded organic remains of the relics of successive generations of animals and plants, and as experience has taught that the metallic deposits differ according to the age of the strata, so for instance, *Tin* is only found in the oldest or lower strata and never was found in the newer, so the doctor has described, with much exactness, these remains. In an appendix to his labors, he has described about 50 species, of which there are many that were not described before, and most of them were not known to exist in our country.

"The committee learn from the report of Dr. Troost that he has commenced an analysis of the various soils, and that it is his object to add to his work an agricultural and chemical description of the nature of the different soils. When this object shall have been attained, the committee believe that the description of these counties will be complete, and when the whole state shall have

been described in the same manner, the committee believe the whole work will constitute a book that will be useful to the State, and particularly useful as a guide for the study of geology, which science is now taught in the University of Nashville and several other colleges.

"The committee consider the memoir of Dr. Troost as highly worthy of publication, but as the production is not of a character similar to the generality of the legal documents which have been presented to the legislature, it being accompanied with a map and profiles of stratification which cannot be executed in this state, the committee deem it advisable to leave the publication to be conducted by the author himself."

In searching the manuscript legislative records in the office of the secretary of state, the following document was found. It is not, as its title would indicate, the second report but a partial summary accompanying the report which is itself not on file. Along with the legislative committee's analysis above, it gives a good idea of the contents of this unpublished second report. His observations on the soils of the three counties examined are appended to his third report and the geological map, perhaps further improved, is contained in his seventh report. The document is as follows:

Annual report of G. Troost, geologist and assayer of the State of Tennessee for the year 1833.

"I beg leave to lay before your honorable body an account of my labours as geologist, etc. of the state. The adjoined pages and map contain the geological description and a delineation of Davidson, Williamson and Maury counties. Nothing is as yet known of the geology of the interior of North America. I have therefore endeavored to describe minutely the various strata which I have been able to examine in the three counties. I have accurately described the accidental substances and organic remains imbedded in the limestone and sandstone. To exhibit to the learned world our true geological position, I was forced to enter, in describing these accidental substances, into long details, particularly respecting the organic remains, which are considered as characterizing the strata. My labour in this respect is not yet complete —the number of organic remains which I have collected in my excursions is so great, that I was not able properly to examine and describe them all. My intention is to render that part of my research as complete as may be in my power, a description of our fossils being a great desideratum for the European geologists. It

is also necessary in order to make this part properly understood that when published, it should be elucidated by representations of those which never have been described, and having been disappointed in my expectations of having them engraved my labours are also imperfect in that respect.

"In describing the accidental minerals occurring in the strata, I speak of their metallic deposits. I have been particular in examining all places where any traces of them did make their appearance and have given my opinion as to the probable extent of these valuable materials which must eventually form one of the sources of our prosperity.

"Next in consideration comes the nature of the soil, after having pointed out its probable origin, whether produced by an alluvion deposited by rivers actually existing, or by an old alluvion, deposited by other causes; or merely by the disintegration of the rocks. I investigated its chemical composition, and its fitness for various agricultural purposes. I collected therefor all the information I could from our experienced agriculturalists, situated on the different soils and ascertained the quality and quantity of their various crops. I have in this respect for the present, made only a few analyses and collected as yet only a few notes which are not yet arranged but will be ready for publication. The knowledge of the nature of our soil cannot be otherwise than interesting to the immigrating part of our inhabitants, therefore although that part does not belong to geology properly speaking, I have thought it of too great importance to omit it.

"My excursions during the spring of this year have been toward the northeast as far as Abingdon in Virginia. I wanted to become acquainted with the formation of that part of the country so rich in salt and plaster in order to see whether it extends into our state or whether similar formations though not connected with that of Virginia obtain in Tennessee: as to the first part of these inquiries I am convinced of the negative and the second must be ascertained by future investigations.

"In that excursion I crossed the coal formation of our state in another direction than I had done in my former excursions, and I am now convinced that it is very extensive.

"Although I am still ignorant of all the geological details of the coal strata, which I will investigate when I shall survey each county separately, I am nevertheless prepared to say that the coal formation makes its appearance in the southern extremity of the Cumberland mountains where it crops out near the Tennessee river in both ridges which enclose the Sequatchy valley. It runs thence in a northern direction to the east of the Crab Orchard mountain where it is associated with excellent iron ore. Continuing in the direction of the mountain towards the east and north, or rather following the right bank of Obiers river, it crops out at

several places, as at Hinlopen in Overton and also Fentress counties where the coal formation seems to have its greater extent, running easterly through Campbell, Morgan and perhaps Anderson counties as far as the eastern declivity of the Cumberland mountains, where again it crops out at several places. In fact wherever the sandstone forms the upper stratum in these counties coal may be found by boring.

"This excursion has convinced me still more of the mineral richness of the eastern part of our state. In Clayborne county between Clinch and Powell's rivers is a vein of zinc and lead ores. The finest marbles abound everywhere. Carter and Washington counties are rich in metallic deposits and several iron works are in operation.

"In a former excursion I ascertained the general geological features of the western part of this state. As the autumn is better calculated to travel through this part, I shall examine some parts of it more minutely during the months of October and November of this year and again take the spring for east and middle Tennessee.

"Although I have collected a large number of geological facts relating to the different parts which I have visited, I am nevertheless not yet ready to report. It requires in order to do this a more minute examination than I have been able to bestow upon it, and this will form the subject of a subsequent report.

"If the subjoined descriptions be considered by your honorable body worthy of publication, I shall wish to have the management of it myself, as it will be necessary to have the map engraved and the proofs properly corrected—besides several additions are yet to be made, before it is fit to appear before the public. As I have mentioned above, notes on the nature of the soil are wanting, some of these analysis are still to be performed and I may yet be able to add a few more descriptions of our fossils or some other natural production of our state."

The third report describes the extent of the coal fields in the state, discusses the marl now known as the rotten limestone, and the soils of the state and concludes with a brief notice of iron furnaces and iron ores. There is subjoined from the unpublished second report the result of the investigations of the soils of Davidson, Williamson and Maury counties.

The fourth report opens with an exposition of the principles of geology and a brief description of the rocks characteristic of each of the divisions from primordial to Tertiary. The report proper describes the Ocoee district

which he had been instructed by the legislature to examine. He calls attention to the roofing slates of east Tennessee and describes the search for placer gold then carried on in a few places in the Ocoee region with indifferent success. He suggests that the Tennessee river once cut across Walden's ridge and flowed down the Sequatchie valley. In a note there is added a list of the fossils he had found in the mountain limestone of the state.

In his fifth report, Dr. Troost gives in some detail a general description of the geology of the whole state, and continues his account of the soil and mineral resources of the counties by a description of Cocke county in which much attention is given to the iron ores. Iron furnaces and iron ore, elsewhere are noticed briefly and mention is made of silver ore and mineral waters. In an appendix 116 species of fossils are listed and a number of them, especially the new species, are described at some length.

In the sixth report the general geology of middle and east Tennessee is redescribed in the light of the work of Sedgwick and Murchison and the terms Cambrian and Silurian substituted for grauwacke. The rocks of middle Tennessee are referred to the Silurian and the fossils found in them are listed and some of them described. A description of Sevier county is given and attention is called to its roofing slate.

The seventh report gives a detailed description of the geology of Davidson county with numerous references to the occurrences of the same strata in adjoining counties. An account is given of the greensand of McNairy and adjoining counties and a list of the reptiles and of the fresh water shells of the state is added. In a supplement a brief account is given of the lead and zinc ores of east Tennessee.

The eighth report describes several routes by which a railroad from Nashville to Chattanooga could be constructed and directs attention to the coal, iron and limestone of the region that would be traversed by the road. In obedience to a resolution of the legislature a report on the marble, or rather limestone, of Caney fork is added.

The first part of the ninth report contains a description of Jefferson county and the second part gives an account

of the zinc ores of the state, and describes the methods of reducing them and of manufacturing brass.

The tenth report was presented to the House on January 12, 1850* and seventy-five copies were ordered to be printed for the use of the House. No edition was ever published and neither the manuscript copy nor any of the copies printed for the House can now be found. Dr. Troost's monograph on the Crinoidea was also submitted to the legislature at the same time and a memorial praying aid in its publication was introduced but was defeated. The report itself was very probably brief since the American Journal of Science in noticing it mentions only the monograph on crinoids. Its information was derived from a letter from Dr. Troost himself.

The nature and variety of Dr. Troost's other writings may be gathered best from the appended bibliography, which has been made as complete as possible, especially as regards his geological reports.

A few family data may be added. Dr. Troost was a son of Everhard Joseph Troost and Anna Cornelia van Haeck. On January 14, 1811 he married Margaret Tage who was born in Philadelphia September 12, 1790. Their children were Caroline, born in Philadelphia, December 6, 1811, and Lewis born at Cape Sable, Md., May 26, 1818. His wife died at Cape Sable, Md., August 3, 1819. His second wife, Mrs. O'Reilly of Philadelphia, survived him a number of years. He had a brother, Dr. Benoit Troost, some years his junior, who lived in Kansas City, Mo. His son Lewis has left one child, a Mrs. Parker, living in or near Mobile, Ala. His daughter Caroline married Albert Stein. They removed to Mobile, Ala., and Mr. Lewis Stein of Spring Hill, Ala. is one of their descendants.

He sleeps in an unmarked and neglected grave in an obscure corner of the old city cemetery of Nashville. The State will be asked at the coming session of the legislature to place an appropriate marker over his grave and thus rescue from oblivion the last resting place of one who gave much of his time and skill to the service of the State in making known the existence or extent of natural resources

* House Jour. for 1849-'50, p. 559.

whose later development has brought wealth and prosperity to their fortunate possessors. The portrait herewith reproduced is from a portrait in oil belonging to the Tennessee Historical Society.

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Vanderbilt University.

NOTES ON SOME ROCKS AND MINERALS FROM NORTH GREENLAND AND FROBISHER BAY.

By B. K. Emerson, Amherst, Mass.

PLATE VI.

Introduction—A large box of rocks collected by Mr. I. I. Hayes, at and around Port Foulke* came into the possession of the Amherst College cabinet, presented by professor Edward Tuckerman, to whom the box was sent by Dr. Torrey because of the lichens with which the rocks are covered.

From the scattered notices in the account of Dr. Hayes' expedition it is clear that the Archaean rocks of the mountain ridges are flanked along the eastern shore of Smith's sound by an extensive series of sandstones and limestones cut by heavy dykes of dark igneous rocks.

The rocks examined are without especial labels except one upon which is written, "Picked up by Jensen while off on a hunt after reindeer," but I am quite sure that the pieces described below came from the near vicinity of the winter quarters of the expedition at Port Foulke, both from their large size, and the great number of pieces of the same rock present, and from the fact that I have for comparison rocks from Etah bay, Sontag's grave, and all the other localities in the neighborhood mentioned in Dr. Hayes' narrative, which with full labels affixed were found in a box of rocks packed by the Arctic explorer, C. F. Hall in Kotzebue

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*The Open Polar Sea, 1867.

sound on his first journey, and which I have described in connection with Hall's collections.†

I have not been able to explain how these rocks, labeled by some member of Dr. Hayes' party in North Greenland, came into the possession of Hall in Rescue harbor, but a comparison of them with the series recently obtained makes it quite certain that these specially mentioned below all came from Port Foulke.

CRYSTALLINE SCHISTS AND GRANITES.

The collection contains coarse granites in great abundance and variety, especially coarse flesh-colored micaless granites, large masses of pink quartz and of orthoclase, more rarely fine grained gneisses, mica schists, granulytes, albite aplyte, hornblende schists, fissile and massive quartzytes, all in no wise peculiar with the exception of one and that the most abundant variety, which merits attention both for itself and for the minerals which it contains. Several large pieces of the rock occur in the collection and specimens of the same from both sides of the bay were present in Hall's collection. In its commonest form the rock is a coarse red granite, a deep red orthoclase making up half its mass and large dark red garnets 1-4 cm. in diameter the other half. The latter are often only shells of garnet material which have compelled granular masses of quartz and a bronze-colored mica to assume the form of the trapezohedron. The garnets are often changed into a massive black green chlorite. Quartz and mica are rare in the mass of the rock.

In other pieces the feldspar is gradually replaced by a rich, deep-blue quartz and the rock grades on the one side into a blue highly crystalline gneissoid granite in which at last the feldspar so entirely and the mica so nearly disappears—the latter remaining wholly in broad wavy films upon the distant foliation faces, and much decomposed into a blackish-green chloritic material—that the rock becomes a massive blue crystalline quartz in layers 1'½ inch thick and of great beauty; or on the other hand into a very even, medium grained mixture of cobalt blue quartz and a rich bronze-colored mica. The quartz contains long, straight

†NOURSE, *Narrative of the Second Expedition made by C. F. Hall*, Washington, 1879, Appendix.

microlites, only, .008 mm. in cross section, which appear black by transmitted light. They may be all rutile since this mineral is common in the biotites forming a sagenitic network so thick as to make them sometimes opaque.

The section contains here and there trains of large cavities with motionless bubbles. The whole section is evenly dusted with minute brown ragged scales (which seem to be biotite) except in a somewhat regular network of branching bands, which do not coincide with partings between the quartz grains.

Another similar specimen of the coarse quartz-biotite rock is of a much deeper cobalt blue and differs very materially in thin section from the preceding. The microlites and sheets of cavities are wanting and the quartz is full of the same minute flat ragged scales of a reddish mineral apparently biotite. Scattered irregularly in the quartz ground are quite large grains of deep blue spinel, often black except on the edges. A similar blue spinel occurs at Frobisher's bay in a rock consisting mostly of phlogopite and calcite which makes part in an Archaean limestone, and we may possibly assume these grains and crystals to have been derived by the granite from an ancient crystalline limestone. These grains are uniformly surrounded by a red brown biotite sometimes in a narrow frill of small plates, sometimes in a broad border of coarse plates. These always show the strongest indications of resorption. Large round grains of a black ore fill the outer portion of the mica plates and gather in the interior in strongly developed beaded rods or fusiform shapes, (often occupying the prismatic cleavage and the diagonal thereto,—the lines of the percussion figure) which become so abundant as to make the plate opaque. These balls extend beyond the edge of the mica plate and even appear apart from the mica in round areas as if the mica had been wholly resorbed.

Many beautiful blue prisms radiate from the spinel or lie isolated ni the mica frill. They are rhombic, have strong absorption, reddish violet parallel with the prism, rich ultramarine blue and colorless at right angles to the same. They seem to be dumortierite prismatic parallel to *b* or *a* *

*Mon. U. S. G. S. xxix, p. 28, 1898.

*This article was written many years ago and mislaid. Since then the question of the cause of the blue quartz so common in the Archaean has interested me and this quartz is so generally without inclusions and strongly strained that I have considered the color to result from this strain, especially since the blue color can be sometimes seen to disappear when the strain is relieved by fissuring. So long ago as 1822 Cleveland cites many localities of the mineral. It is found in Bohemia, Macedonia, etc.; in the United States; in Virginia: near the Blue Ridge, in Amherst and Campbell counties in amorphous masses (T. D. Porter). In Pennsylvania: Chester county; and near Abington, Montgomery county, is found an amorphous blue quartz (Seybert). About two miles west from West Chester, it contains zircon (Lea). P. Cleaveland, (Treatise on Mineralogy and Geology, 2d Edition, 1822, I, p. 237.)

Keith reports it from the Catoctin belt as the constant accompaniment of the pre-Cambrian granite in a small portion of its extent. At certain points the blue quartz granite is not peculiar microscopically, but is macroscopically striking from the brilliancy of its color. The blue quartz is in original crystals and in veins and patches.

I have found the mineral everywhere characteristic of the pre-Cambrian rocks of western New England and western Sweden. In eastern central New England post-Carboniferous blue quartz granites occur and I have recently described beautiful pre-Carboniferous blue quartz porphyries from East Greenwich, R. I. I have seen similar porphyries in Finland.

It is curious that this deepest colored blue quartz should contain cobalt ores, deep blue spinel and the rich blue dumortierite. The two last may contribute to the blue color making it deeper than usual but they do not explain the phenomenon in its wider appearance.

The broad biotite-dumortierite border seems to have been formed by the solvent action of the heated alkali-silica solutions, and then to have been in large measure resorbed.

Spots of millerite spread through the rock in thick curved sheets as if it replaced the mica. It gives with the blowpipe reactions for sulphur and nickel alone, has H. 3.5, is very brittle and gives a dark streak. Exceptionally large cleavage pieces a quarter of an inch across were obtained. The cleavage is nearly perfect parallel to a rhombohedron of 144 degrees 15 minutes a mean of several measurements with reflecting goniometer. The color is bright brass yellow.

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* An. Rep. U. S. G. S., xiv, p. 300, pl. xxiv.

Erythrite, annabergite in thick crusts, and a very beautiful bunsenite accompany the sulphides and have resulted from their decomposition. All these minerals were destroyed in the burning of the Amherst College collection.

Sedimentary Rocks—Buff, massive sandstones, with the finest ripple marks, red, well-bedded, pebbly sandstones, and buff, slaty sandstones are very abundant, and the latter occur also somewhat indurated and finely jointed, or baked masses of a thick-bedded, buff, cherty limestone. The figure shows a curious banded concretionary structure in deeper shades resembling the landscape marble from Cotham in England. It is a distinct schlieren structure in a sedimentary rock, as if a heavier layer had settled upon a lighter, and the latter had at stated points risen up into the former. The lines of flow marked by a delicate banding, and expanded outwardly into a fan structure. See analysis I.

Grey limestones with traces of brachiopods and large pieces of chert accompany the sandstones and closely resemble the limestone of the Niagara period from the Parry islands, while the sandstones have been compared by McClintock to the series in Byane, Martin's island, which are referred by Houghton to the base of the Carboniferous.* The sandstones here described resemble closely the New York Potsdam, and seem to form a fringe along the Archean hights to the north and south of Port Foulke, as the former do around the mountains of northern New York.

One large piece of the limestone has still attached to it a mass of chert of a pale leek-green color, of fine conchoidal fracture and porcellanous appearance, and many large pieces of the same rock occur in the collection. The rock resembles so exactly a compact felsyte tufa that I had thought it at first from its macroscopical appearance to be such, but its infusibility, and relation to the limestone, and the fact that it resembles also almost equally well slides of chert and hornstone, determined its reference as above. Microscopically it shows a colorless, transparent, amorphous mass and must be largely opal. It is filled with minute, reddish, non-polarizing grains, agglomerated into semi-opaque, often spherical, balls, which give the mass a "cumulitic" ap-

*Jour. Roy. Dublin Society, 1857, p. 199.

Fig. 1. BANDED LIMESTONE. Frobisher Bay. The upper half shows two sections about ¼ inch apart of a banded limestone of crushed strawberry color. The lower two similar sections of a contorted banded limestone, grey, above, deep brown-shaded below.

pearance. A small vein of granular quartz runs across the slide containing highly refringent globules of small size with bubbles. See analysis II.

The following analyses were made for me in the laboratory of Amherst College, by Mr. Edward C. Smith:

Analysis I.—Compact Banded Limestone. See page 98.
Analysis II.—Green Hornstone. See page 98.

I.

SiO^2	5.89 per cent.
CO^2	43.44 per cent.
Fe^2O^3	1.05 per cent.
Al^2O^3	0.81 per cent.
CaO	29.73 per cent.
MgO	19.06 per cent.
Total	99.98 per cent.

II.

SiO^2	84.00 per cent.
Fe^2O^3	7.20 per cent.
Al^2O^3	0.92 per cent.
CaO	0.47 per cent.
MgO	1.07 per cent.
Na^2O	1.77 per cent.
K^2O	2.07 per cent.
H^2O	1.83 per cent.
	99.33 per cent.

BASIC ERUPTIONS.

Dioryte.—Port Foulke. A massive black rock with the shining jet-black hornblendes just visible to the eye, and the plagioclase of glassy freshness. It has with the microscope the simplest dioryte-texture and the fieldspar is labradorite.

Quartz Diabase (Kongadiabase). This agrees closely with the rock from Rawdon, Quebec, figured in Rosenbusch, Gesteinslehre, p. 329. The rock is dull black with small reddish spots. Flat blades of black angite sometimes a half inch long appear quite abundantly. They have a central suture and a transverse striation. These blades are found under the microscope to be wholly altered to a fibrous mass of dark green delessite which is quickly decomposed by acid

leaving a white fibrous residue. It is assumed that the mineral was augite because it exactly resembles the long blades of augite found in the peculiar variant of the Holyoke diabase and called plumose diabase by the writer in a communication to the Geological Society in 1903. The flat plate is formed by the large development of two opposite prism faces. The central suture is the common twinning plane. The transverse parting is the basal cleavage. All the magnetite is concentrated around these blades and a few of the feldspars of the first generation in an unusually thick layer. The magnetite cleavage can be clearly seen on fragments treated with acid. The rock on this side allies itself to diabase. On the other hand the dark flesh-colored spots which represent the ground have an aplitic aspect. A few ideomorphic plagioclase crystals occur, rarely, in albite twins, mostly limpid but partly changed to a green mica in coarse scales. Anorthite and oligoclase could be determined optically. A few long needles of a colorless hornblendic mineral appear.

Surrounding these ideomorphic minerals is an abundant ground made up of an intimate mixture of quartz and feldspar which imitates every form of the macroscopic pegmatyte structure and avoids the worm-like, granophyric or myrmekitic structure. The larger anhedral portions of quartz contain sparingly the rigid needles common in granitic quartz and send out into the feldspar long parallel equidistant bars which intersect at angles of about 40 to 50 degrees, and form a lace work of great beauty. In other feldspars stouter quartz rods with many crystal faces produce exactly the aspect of common graphic granite. The whole is pale brown-dusted. This ground has also a close resemblance to the ground in the plumose diabase mentioned above. It is there associated with palagonite which is wanting here. The micropegmatyte texture seems to depend on the unusual influence of water.

Diabase Aphanyte.—A fresh, exceedingly fine-grained diabase, which would not be easily distinguished macroscopically from the finest varieties of our Triassic diabases except for the slightly brownish shade of color. Microscopically one finds augite filling the crevices among the other

constituents, magnetite abundant in angular crystalline groups, plagioclase with extinction 20 degrees for the smaller 25 degrees for the much larger of the minute acicular crystals, the whole with complete ophitic structure. The glass basis is present in small portions, either in grotesque ramifications in the larger feldspars, at times arranged in a beaded layer parallel to their boundaries or in isolated blebs. It is here often only partially devitrified but where it is wedged in the interstices of the very fresh crystalline constituents it is a reddish-grey granular mass showing aggregate polarization.

Diabase.—This rock is a crumbling pseudo amygdaloidal mass much decomposed and carrying calcareous and chloritic amydules. It is considerably coarser than the preceding variety but the constituents can not be distinguished without a lens. Under the microscope it has the aspect of a common diabase. The feldspar is abundant but wholly decomposed. In the freshest portion the augite is very little changed. Many large irregular cavities are filled with a red-brown radiated, fibrous mass of altered delessite showing a black cross when rotated under the nicols. These two rocks may very probably belong to a single series of dykes or have been derived from the border and center of a single large stock.

Pickryte.—The third mass is fine-grained, greenish-black and fresh in appearance, and in it one detects with a lens scales of red mica and very rarely a triclinic feldspar. Microscopically it proved to be an unusually fresh and very interesting pickryte—an olivine-diallage-augite rock with some accessory plagioclase, which latter was wholly wanting in several slides, in others reached an amount which tempted one to associate the rock rather with the gabbros, which it resembles in texture. The olivine which makes up certainly three-fourths of the mass, is often present in large and well formed crystals, and in smaller crystals crowds the other constituents. It is often quite fresh, often much decomposed and where the change is well advanced after the formation of the usual broad bands of yellowish serpentine, it turned in a new direction and the rest of the crystal has gone over into a mass of plumose scales which polarize in

pale bluish shades like talc. Often also the serpentine is gathered in bright emerald or bluish green patches. The diallage is often quite fresh and shows clearly two pinacoidal cleavages, with rarely any trace of the prismatic cleavage. It is pale yellow with few of the enclosures characteristic of the mineral, shows the usual fibrous structure and often distinct twin lanimae interposed in the plane of the perfect cleavage. It is in many cases advanced beyond the olivine in the change to serpentine and the brightly colored varieties of the latter mineral are most closely connected with it.

Other smaller and often perfectly outlined crystals possess the cleavage and show the ordinary twinning of augite and are often enclosed in the plagioclase.

The feldspar, wedged in sharply angular pieces among the other constituents, shows twin-lanimae of very unequal widths, with extinction 21 to 27 degrees. In one section parallel to M. the extinction was 29 degrees. Octahedra apparently of picotite occur in the olivine and serpentine, while magnetite appears both as an original constituent and in smaller granules in the serpentine.

The order of crystallization is picotite and magnetite, olivine, diallage, augite, plagioclase. The rock affords slides of great beauty from the very regular forms of its crystals and the beautifully developed sepentinous change.

In this connection I wish to call attention to certain allied eruptive rocks from Frobisher bay, among the collection made by C. F. Hall, which I studied twenty-five years ago with improvised optical apparatus.

Hornblende-bearing Diabase.—This is a dark fresh looking trap the feldspar needles just showing to the eye. The feldspar rods are labradorite with irregular twinning in few bands. A broad central area is dusted brown, and this dust decreases toward the edge, and a strong undulose extinction goes parallel with it, the angle of extinction decreasing toward the border. Large grains of a pale coarse-cleaving pyroxene occupy the meshes, mostly uralitized. A considerable number of large grains of an original greenish-brown hornblende appear. This was described in Hall's Narrative, p. 568, as quartz dioryte.

Alnoyte.—So many large blocks of this rock were in

the collection that it is quite sure that they came from Rescue harbor, Field bay, where Hall took ship for his return.

They are a brownish-black trap-like rock, massive to platy, with many deep-red biotite scales showing with the lens.

The rock effervesces for a long time with acid and this brings out light-colored spots full of needles of a pyroxenic mineral.

Under the microscope a few large, lemon-yellow serpentine pseudomorphs after olivine are surrounded by a broad band of the large deep-red biotites which have an almost black border. The change of the olivine is sometimes in whole or part into an aggregate of carbonates. Long, square prisms of a colorless highly refractive pyroxene occur. Another pyroxene appears in tufts of long prisms and needles which radiate into calcite-filled cavities. They are red-brown in the central half and pale green at the ends. Some are wholly dark greenish blue to nearly black. The mineral is much like aegerine, but extinguishes at 37 to 41 degrees and so is a peculiar pyroxene which has strong absorption and dispersion and on being rotated slightly from the position of extinction shows red-brown on one side and clear blue on the other, suggesting titanaugite.

Probable remnants of nepheline show uniaxial figure and low refraction. Many of these phenocrysts have so sharply the trapezohedral cross section as to suggest leucite, but these are decomposed in the same way as the prismatic forms.

Half the field is taken up with octagonal or nearly spherical phenocrysts, which are just visible to the eye. They are now mostly decomposed into a mixture of calcite and colorless needles. Some show negative uniaxial cross and high refraction and polarize in pale blue tints and all are probably mellilite. See "Geology of Frobisher's Bay," in Hall's Narrative, p. 571, 1879.

Alnoyte Porphyry.—Another distinct variety is much finer grained than the preceding. It is aphanitic to the eye and less distinctly porphyritic to the microscope.

The biotite appears only in the ground with microlites of mellilite. The sharp crystals of amber pyroxene are un-

changed. Those of mellilite are changed as before. The olivine phenocrysts are double the size of the others and are sharp as needles, except that they enclose blebs of the ground. Their decomposition is peculiar. They are sometimes a homogenous matted mass of serpentine fibres lacking the common decomposition along fissures. They are generally swarming full of the prisms of the titanaugite described above, in radiating tufts, or growing into the interior of the fibrous mass from the surface. Sometimes they form a loose network through the whole. They are sharp, square prisms, bounded by the pinacoid faces.

The specimen had a greasy label in Hall's cramped hand: "Found at Is-se-luk-ju-nor. Between Frobisher Bay and 'Rescue Bay;' on the land as we pass from head of latter to the inlet that makes up within 2½ miles. (This route is the one in winter in passing between Oo-pung-ne-wing and Rescue Harbor.) Given me by Kou-isse."

This was doubtless at Bayard Taylor pass. See Hall's Arctic Research Expedition; map.

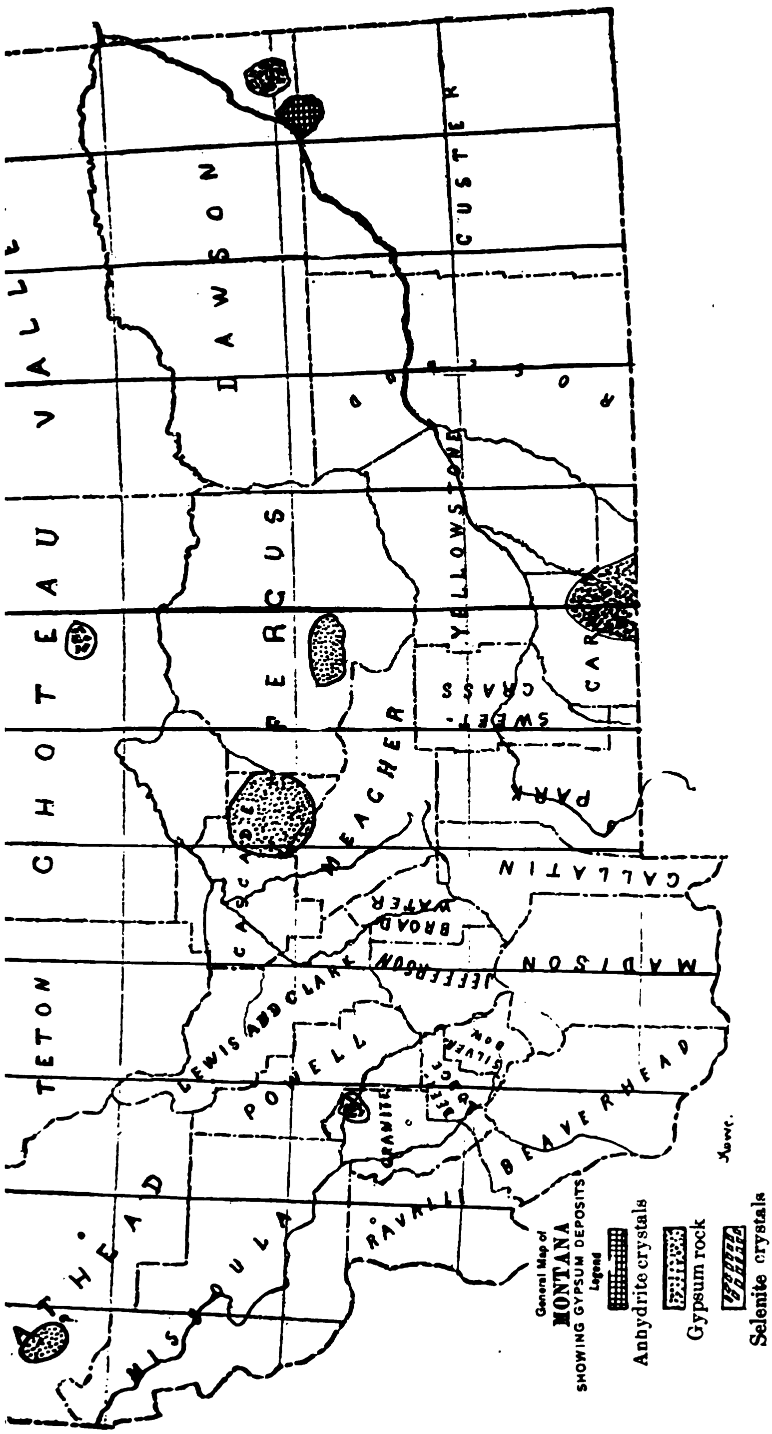
The age of these eruptives cannot be told. They are associated with a large range of Archaean rocks—granites, granitytes granulytes, magnitite gneisses, coccalite limestones containing ruby spinels, but adjacent, are probably Carboniferous rocks, and certainly highly fossiliferous Lower Silurian rocks from which in the article cited I described a large number of fossils.

MONTANA GYPSUM DEPOSITS.

By JESSE PERRY ROWE, University of Montana, Missoula.

PLATES VII, VIII, IX, X.

Little has been written concerning the gypsum deposits of Montana, as the discovery and economic development of the beds in the state date back but a few years. Perhaps the first commercial use made of native gypsum in Montana was in the year 1894—and the first discovery the year previous. The state, however, can boast of as large gypsum


General Map of
MONTANA
SHOWING GYPSUM DEPOSITS
Legend
Anhydrite crystals
Gypsum rock
Selenite crystals
TETON
CHOTEAU
VALLEY
DAWSON
CUSTER
FERGUS
YELLOWSTONE
SWEET GRASS
PARK
GALLATIN
MADISON
BEAVERHEAD
JEFFERSON
BROADWATER
MEAGHER
LEWIS AND CLARK
POWELL
GRANITE
SILVER BOW
RAVALLI
MISSOULA

Plaster of Paris and Stucco Miill near Armington, Mont.

Gypsum Deposit near Armington, Mont. on Belt Creek.

Gypsum Deposit Eight Miles Southeast of Bridger, Mont.

neral View of Anticline and Gypsum Deposit eight miles southeast of Bridger, Mont.

View of Gypsum Deposit near Bowler, Mont.

Gypsum Deposit near Crockett, Mont.

deposits as any state in the Union, and in a few years this natural resource will be of great benefit to her citizens.

The gypsum deposits in Montana may be divided into three general fields; the North, Middle, and South Fields. These fields follow the contour of the mountains and run from northwest to southeast through the state.

Little is known of the North Field, but it is claimed that some good deposits are located near Libby, Flathead county, Montana, and until recently a plaster of Paris and stucco mill was in operation at that place.*

The Middle Field is located in the counties of Cascade and Fergus. Two large deposits are found in this field. One deposit near the towns of Armington and Kibby in Cascade county; and the other in the Big Snowy mountains, of Fergus county, near Portuguese. The South Field is located in Carbon county, near Bridger.

The selenite variety of gypsum is found in all the counties of Montana east of the rockies. It occurs in the upper Cretaceous formations, but seldom is found in commercial quantities. "Very commonly it impregnates the waters both of streams and springs, making them unfit for use. At Hunter's Hot Springs, on the North bank of Yellowstone river, about 20 miles east of Livingston, the hot waters are now depositing gypsum and the old hot spring fissures are filled by a mass of gypsum and stilbite. Up to the present time these deposits, although of considerable extent, have not been utilized."*

During the summer of 1902 the writer found a vein of selenite in the southern part of Fergus county, near Folsom, which is about 18 inches thick and several yards in length. This deposit is in the Laramie. Many such places occur in the state but the areas are small and do not warrant an attempt at commercial production.

Crystals of selenite gypsum are found in quite large quantities in the Laramie clays of Dawson county,† and near Bear Paw mountains, in Choteau county.

* Eighth Report of Bureau of Agriculture, Labor and Industry of the State of Montana.—FERGUSON.
*W. H. WEED. In Bulletin, U. S. Geological Survey, No. 223.
†J. P. ROWE—*Nodular Barite and Selenite Crystals of Montana:* AMERICAN GEOLOGIST, vol, 83, p. 199.

Anhydrite gypsum crystals are found 14 miles west of Wibaux, Montana, in the "bad lands" of Glendive creek, Dawson county. The butte on which the crystals are found is one of the highest in this region, and is capped by a scoriaceous volcanic rock. The crystals are found about 30 feet below in a "gumbo" clay. The transition of selenite to anhydrite is beautifully shown. The heat of the overlying lava thus caused the change. The crystals are found in the Laramie and are the only native anhydrite crystals so far known in Montana.

The middle and southern beds are the only ones being worked at present, and only one mill is being operated at each place.

The Middle Field.

The principal beds now being worked in this field are located in the northwestern part of Cascade county and cover quite a large area. According to Weed "the series of beds may be traced from the Missouri river eastwards along the flanks of the Big Belt mountains to Riceville on the Neihart branch of the Great Northern railway; thence eastward to the town of Kibby, and thence around the flank of the Little Belt mountains in a nearly continuous exposure to the vicinity of Castle mountains. Southward from that locality the same horizon can be traced by its red shales, but the gypsum does not occur, so far as known, in sufficient purity or thickness to promise commercial importance."

This field was visited during the past summer and found to be in a flourishing condition. Mr. A. J. Voight, the present president and manager of the only stucco and plaster of Paris mill in this field, made it possible for the writer to investigate the beds and mill and closely examine the products. Mr. Voight formerly owned and managed the Kibby plant, but after this latter burned, the beds nine miles northwest of Kibby and six miles above Armington were opened and in 1900 the new or present plant was installed. "The mill of this plant is located directly on the Neihart branch of the Montana Central railway six miles above Armington, on Belt creek and thirty-four miles from Great Falls. The mine is directly back of it and sufficiently high on the hillside so that gravity is largely helpful in handling the rock." Some-

time back, wagons were used in transporting the rock gypsum from the mines to the mill, but there was installed during the past summer a gravity tram car system which greatly facilitates this part of the work and somewhat lessens the expense of transporting the raw material. The gypsum is dumped into an immense bin, and "directly from the rock bin" it is passed "through a 12x14 inch Blake crusher which crushes it to about one inch; then through a Gates crusher, which reduces it to one-quarter of an inch; then it is elevated to a trammel which separates the coarse from the fine, all over 40-mesh going down through a gravity pipe into a French burr which reduces everthing to 40-mesh or finer; from the burr it is again elevated to the same separator, whence it travels by gravity to a bin over the calciner. The calciner holds about three tons and in this mechanism the gypsum is dehydrated by subjecting it to heat at 260 degrees Fahrenheit for two and one-half hours usually. From here the plaster of Paris is conducted to a storage bin where a retarder and hair are added, then through a Broughton mixer which finishes the stucco process. The capacity of the mill is thirty tons per day, of 24 hours, which it regularly turns out and loads directly in the railroad cars for shipment. More than one-half goes to Seattle and Spokane, the balance being marketed at Great Falls, Butte, Missoula, Helena and other Montana towns.

This mill is by far the better equipped and capacious of the two now operating in the state.

Stucco or wall plaster from this mill was used in the

Victoria Building, Spokane, Washington.

State Capitol Building, Helena, Montana.

U. S. Post Office Building, Butte, Montana.

U. S. Post Office Building, Helena, Montana.

Hennessey Merc. Co. Building, Butte, Montana.

Court House Building, Great Falls, Montana.

Court House Building, Kalispell, Montana.

Masonic Temple Building, Butte, Montana.

Yerrick Building, Missoula, Montana, and many others.

The above readily shows that the Montana product is equal to the eastern product and is being quite generally used throughout the northwest.

The company operating this mill, or the "Montana Aluminum Plaster Co." manufactures five different products from the raw gypsum—stucco, plaster of Paris, aluminum hard finish plaster, sand plaster and calcimine of various colors. The annual product from this plant is about 1,800 tons.

The mill and mines are lighted with electricity, generated by means of a small dynamo at one end of the mill. The mill at present is run by steam but the company expects to dam Belt creek within another year and thus run on a more economical basis. The mill is within twenty yards of the railroad, thirty yards of the creek and fifty yards of the mines. Everything is ideal for a plant of this sort.

The Gypsum Beds.

The beds found here are between twenty-five and thirty feet thick, and extend over an immense area. They are nearly horizontal, having a slight dip to the northwest. The gypsum itself is quite pure (see analyses) but is interstratified somewhat in places with considerable clay.

The gypsum is not more than from 100 to 300 feet below the surface and is capped by and rests upon a hard compact limestone; several fossils were gathered from the rock above and sent to the U. S. National Museum for specific identification and the horizon was pronounced Jurassic.

From the dip, geological formation, and other indications the beds here are pronounced the same as at Kibby, nine miles away. If this be true the field at this place has by far the largest productive area of any in the state. The beds thin out to a few feet at Kibby and most of the material worked there was exposed.

The other bed that belongs to this, or the middle field, is located in the Big Snowy mountains, near Portuguese, about thirty-five miles south of Lewiston, Fergus county. The material is of a very good quality and it is claimed that an immense ledge is exposed. No development of any consequence has ever been done here; but since the railroad now passes within a few miles of the deposits, good use is expected soon to be made of them.

The South Field.

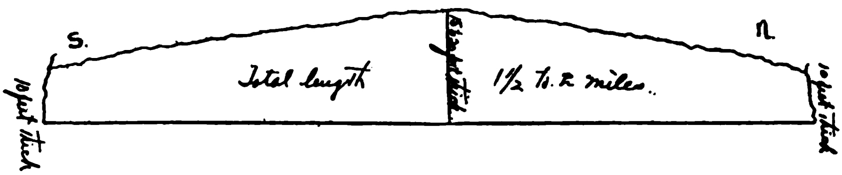
The productive part of this field is located wholly within Carbon county, and "this series of beds then extend southward into the Big Horn basin and can be traced into the mountains of Wyoming."

There are three exceptionally fine outcrops in this field. At present only one of the three is being worked. The *smallest or first outcrop* of this field is located about eight miles south and east of Bridger and at this outcrop is located the only other gypsum plant in the state. The mill is much smaller, but similar, to the one near Armington. From ten to fifteen men are employed at the mill and in the mines, and the products, plaster of Paris and stucco, are hauled to Bridger from where it is shipped by rail to various points in the state. The annual output from this plant is very much smaller than at Armington. The mine is located nearly a half mile from the mill and the raw gypsum is hauled this distance also. The deposit that is being worked is from ten to twelve feet thick and is fairly pure gypsum. A tunnel (see cut) is run into the vein about 300 feet and the rock after being blasted down is hauled out by means of tram cars on ordinary steel rails.

The beds dip a considerable to the northeast and form part of a beautiful anticline (see cut). Beneath the gypsum several feet, near the apex of the anticline, exceptionally good oil shale is found.

This gypsum deposit has been worked for some time but owing to the distance from a railroad and the high price of teaming, it is not an extremely profitable undertaking. The refined gypsum products cost $4 per ton freight in shipping to any large cities of the state, and the material itself sells for about twice that figure. With high teaming rates and one-half of the selling price taken for freight no large profit is made on the material. However, it is paying a small dividend and the mill still continues to run. The altitude of this bed is about 4,200 feet.

The *second outcrop* is between eight and ten (see sketch) miles from the first, and, while it has never been developed to any great extent, it has been worked enough to show that it is much thicker and as free from interstratified



Longitudinal Section of Gypsum Deposit Near Bowler, Montana

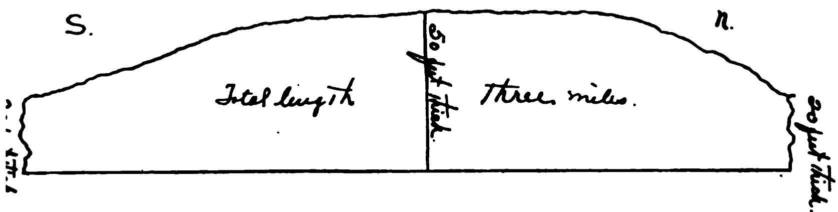
clay as the first deposit. The gypsum is as pure as the former and the area of the bed much greater. A splendid outcrop of from one to two miles is shown and the bed is from fifteen to twenty feet thick. It is quite near the southern border of Carbon county and also of the state, and is only one and one-half miles from Bowler, a station on the Cody branch of the B. & M. railway. This is a good deposit and a spur from Bowler could be run to the bed with very little grading. It will not be long until a mill will be placed at this outcrop to handle this immense deposit.

The *third* and by far the most promising and largest bed of this field, and the thickest, if not the best bed in the state, is located about 16 miles south and east of Bridger and about six miles northeast of the first outcrop, and four or five miles north of the second outcrop. This deposit is owned by Messrs. Hanley and Hough of Bridger as is also number two.

This bed is an exceptionally fine one. At the southern outcrop its thickness is about twenty feet, and it gradually grows thicker to the northward until it reaches a maximum thickness of fifty feet. This is about one and one-half miles from the first southern outcrop. This maximum thickness continues for some distance when a gradual thinning out begins until about three miles north of the first outcrop, where the thickness is about fifteen feet. The deposit has a north and south strike and dips a few degrees to the southwest. The material is as pure and the beds as free from clay as any in the state. It lies immediately on the "red beds" or red sand and shale formation. The Red Beds in this region are from 400 to 600 feet thick, having a northwest and southeast strike and continue for many miles. The gypsum outcrops which cap the Red Beds may be traced for at least fifteen miles. The beds are undoubtedly the same

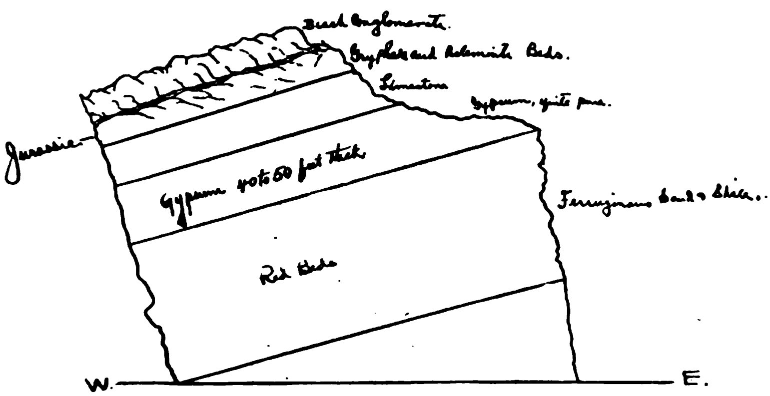
geological formation and also a continuation of the gypsum beds farther south in Wyoming.

This bed is about four and a half miles from Crockett, a station on the B. & M. railway branch line to Cody. The altitude of the bed is 4,800 feet. The valley through which the railroad passes is probably 400 to 600 feet lower than the gypsum outcrop. From Crockett to the base of the cliff on



Longitudinal Section of Gypsum Deposit Near Crockett, Montana.

which the gypsum occurs, it is almost perfectly level, making thereby an easy transportation of the gypsum or gypsum products to the railroad. The gypsum at this place is capped by a hard thick limestone. This limestone formation is exposed to the west and this surface rock covers several hundred acres. The limestone is covered, in some places, by a thick formation bearing numerous Gryphaeæ and Belemnites, and again above this is found a very hard compact reddish conglomerate with grains varying in size from a hickory nut down.



Cross Section of Gyspum Deposit near Crockett, Montana.

This last gypsum deposit is such a promising proposition that a mill is expected to be placed on the property and in operation within another year.

It thus may readily be seen that the commercially productive gypsum deposits lie on the eastern base of the Rocky mountains or in other words on the foot-hills of the main range. It may also be seen that the deposits are numerous, quite thick, and fairly free from impurities. They also have a wide range, running across the state from northwest to southeast, thus making it possible to compete in every town in the state with outside products.

Geological Formations of the Gypsum Deposits.

According to Weed the middle field belongs to the lower Carboniferous. The writer collected several good fossils from this locality during the past summer and found that the gypsum deposits lie directly upon (lower Carboniferous) limestone. The fossils gathered from the limestone are too poor for specific identification, but Dr. T. W. Stanton recognized the genera, Trigonia, Pleuromya, Cyprina (?) and Natica (?) all from the Jurassic. Farther west this dips under the Cretaceous. The beds from all paleontological evidence belong undoubtedly to the Carboniferous.

Not so with the southern beds. According to Darton these beds rest immediately upon the Triassic inasmuch as they rest upon the typical "red beds." There is no paleontological evidence here that the "red beds" are Triassic, but immediately above the gypsum deposits, stratigraphically and paleontologically, the formations belong to the Jurassic. The fossils found from fifty to seventy-five feet above the gypsum deposits in Carbon county show the typical marine Jurassic as found in the northwest. Some of these fossils were identified by Dr. T. W. Stanton of the National Museum and they were Ostrea, sp., Gryphaea calceola var. nebrascensis M. & H., Belemnites densus M. & H. The southern beds are without doubt in the same formation as those in Wyoming, and according to Knight, it is believed that the gypsum-bearing beds of Wyoming will prove to be Permian. So until farther paleontological evidence is found

these beds can be assigned definitely to neither Permian nor Triassic.

ANALYSES*

Near Armington, Montana.		*Near Bowler, Montana.*	
CaO	33.101	CaO	33.023
SO^3	45.939	SO^3	45.935
Water	20.960	Water	21.042
Total	100.000	Total	100.000

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The Geomorphogeny of the Upper Kern Basin. By ANDREW C. LAWSON. (University of California Publications. Bulletin of the Department of Geology. Vol. 3, No. 15, pp. 291-376.) Price 65 cents.

This paper gives the results of an excursion into the high Sierra at the southern limit of Pleistocene glaciation. The larger features of the region embrace (1) a *high mountain zone*, including the *summit region* and a *sub summit plateau*, the last representing a partially developed peneplain, (2) a *high valley zone*, which includes extensive areas of the upper Kern basin from 8,000-11,000 feet above sea level and which represents a second period of partial baseleveling, (3) the *cayon zone* the valley of the Kern and its tributaries which have been cut deeply into the floor of the plateau which comprises the high valley zone. The paper takes up in detail the erosive work of ice during the Pleistocene.

Two new hypotheses of general interest are offered in the course of the paper. First, that the flattened summits of some of the higher mountains represent substantially the contact surface of the granite batholith of the Sierra Nevada and the overlying metamorphosed sedimentaries. The discussion seems to leave this as an interesting suggestion rather than as a well-supported theory. The second hypothesis is that the thirty-mile rectilinear north and south course of the Kern valley is determined by a line of rift. The discussion leaves this as a much more probable explanation, which is especially satisfactory when we are seeing fracture-oriented drainage networks evolved by guess-work in other regions. Certain peculiar buttress-like forms, *kern buts*, are explained as due to the differential slipping of portions of the west wall of the Kern canyon.

No mention is made of more than one glacial period. The Kern canyon is U-shaped in its glaciated portion, but professor Lawson believes that the glacier had but small share in cutting the valley. Hanging-valleys are mentioned but are not considered as evidence

* Analyses made by W. O. Dickinson, Assistant in Chemistry.

bearing on the question of glacial erosion. It seems very doubtful if the amount of material in the terminal moraine in any measure represents the amount of glacial erosion by the glacier; terminal moraines of valley glaciers are often much smaller than the lateral moraines and in many cases the larger part of the material removed has been carried down valley beyond the moraine. While the amount of erosion assigned to the glaciers in their middle and lower course is insignificant, the amount credited to glacial cirque erosion is very great. Professor Lawson agrees with Mr. W. D. Johnson as to the importance of this factor in mountain sculpture and believes that by this process the surface of the upper part of the range has been reduced over large areas to a distance of hundreds of feet.

The paper not only gives an excellent idea of the high Sierra in this particular area, but will be very suggestive to any one who is interested in the study of land forms in high mountains. L. G. W.

The Geology of the Mount Lofty Ranges. Part 1. The Coastal District. By WALTER HOWCHIN, F. G. S. (Trans. Roy. Soc. South Australia, vol. xxviii, 1904.)

The paper describes at length the Cambrian succession as found in South Australia. There is a historical introduction describing the work of A. R. C. Selwyn, G. H. F. Ulrich, Ralph Tate, and other pioneers.

Mr. Howchin finds the following order in the South Australian Cambrian:

A Purple Slates, quartzytes and limestones.
B Silicious, blue, pink and dolomitic limestone.
C Banded fiine grained clay slates and shales.
D Glacial till, grit, etc., with erratics.
E Silicious and felspathic quartzytes and phyllytes.

The present article describes rocks of the first three divisions.

In division A beds of limestone are found (up to 100 feet in thickness) composed almost exclusively of the remains of Archæocyathinæ. The Lower Cambrian age of this division is also determined on the authority of Etheridge and of Tate, by the presence of Microdiscus and Salterella.

Division B contains limestones, etc., that are of considerable economic importance being used for "road metal" and the manufacture of Portland (hydraulic) cement.

There are numerous stone quarries in the slaty rocks of Division C, the material taken out being used for building purposes in the city of Adelaide.

Several fine plates showing flexed and distorted strata of division A at Curlew point and of division B at Field R accompany the article. There is also a plate of sections, and a map showing the distribution of the several members of this series. G. F. M

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CORRESPONDENCE.

FORAMINIFERA COLLECTED FROM THE BLUFFS AT SANTA BARBARA, CALIFORNIA. During a recent visit to Santa Barbara the writer collected a number of Foraminifera from the Pleistocene beds in the Bryozoan sand which is beautifully exposed on the beach and also a number from the same series several hundred feet higher up in the hill south of the city. While the species present in these two horizons appear to be almost identical they vary remarkably in the number of forms present. For example in the lower beach bluff the species most abundant, Polystomella crispa (Linné), is not at all common in the upper hill series. Other forms are plentiful above but seem to be scarce in the lower bluff.

The fauna is decidedly north temperate, belonging to the series described by Parker and Jones in the North Atlantic and Arctic oceans of to-day. There are however a few, belonging to the Miliolidae, which appear to belong somewhat farther south. There are a large number of Miliolidae belonging to several types of which Miliolina seminulum is the most abundant, and of the biloculine type Biloculina ringens is all abundant in the hill series and rather rare in the bluff beds below. The Lagenae present in both horizons are most varied and beautiful and are best separated from the matrix by soaking and floating off on water. The list of species identified is as follows. Unless otherwise mentioned the species belong to both the beds at the top of the hill below the city and also in the bluff along the shore near the wharf.

The formation from which these Foraminifera are obtained has been very ably described in a monograph by Ralph Arnold in the *Mem. Cal, Acad. Sci.* vol. iii, 1903. (The Paleontology and Stratigraphy of the Marine Pliocene and Pleistocene of San Pedro, Cal.)

	Near Hill-Crest.	*Beach-Bluff*
Biloculina depressa d' Orbigny.	Rather Common	Rare
" ringens (Lamarck).	All Abundant	"
Bolivina punctata d' Orbigny.	Rare	"
Bulimina subteres Brady.	Absent	"
Cassidulina crassa d' Orbigny.	Not Common	"
" laevigata d' Orbigny.	All Abundant	Not Common
" subglobosa Brady.	" "	" "
Discorbina globularis (d' Orbigny).	Not Common	Com & Large
" turbo (d' Orbigny).	Absent	Common
" vilardeboana (d' Orbigny).	"	Rare
Gaudryina pupoides d' Orbigny.	One	One
" rugosa d' Orbigny.	Absent	"
Globigerina bulloides d' Orbigny.	Not Rare	Not Rare
Lagena globosa (Montagu).	Several	Rare
" gracilis Williamson.	Several	
" lagenoides (Williamson).	Rare	
" laevis (Walker & Boys).	"	Rare
" marginata (Walker & Boys).	Abundant	Abundant
" melo d' Orbigny.	"	Not uncommon
" quadrata Williamson.	Several	Rare

" semistriata Williamson.	One	
" squamosa (Montagu).	"	Rare
" striata d' Orbigny.	Abundant	Not uncomon
" striatopunctata Parker & Jones.	Two	
" sulcata (Walker & Jacob).		Rare
Miliolina auberiana d' Orbigny.	Rare	
" bicornis (Walker & Jacob)		Rare
" cuvieriana (d' Orbigny).		Several
" linnaeana (d' Orbigny).		One
" oblonga (Montagu).	Several	Rare
" pulchella (d' Orbigny).	Four	Rare
" seminulum (Linné).	Abundant	Abundant
" tricarinata (d' Orbigny).	Several	Common
" trigonula Lamarck.	One	"
" venusta (Karrer).	"	
Nodosaria obliqua (Linné).	Fragment	
" vertebralis (Batsch).	"	
Nonionina depressula (Walker & Jacob).		Two
" scapha (Fichtel & Moll).	Common	Common
" stelligera d' Orbigny.	Abundant	Not common
" umbilicatula (Montagu).		Rare
Polymorphina communis d' Orbigny.	Rare	
" complanata d' Orbigny.	Six	
" compressa d' Orbigny.		One
" lactea (elongate Var. W & J)	One	
" problema d' Orbigny.	"	
Polystomella crispa (Linné).	Not very com.	All abund.
" subnodosa (Munster).		Rare
Spiroloculina tenuis (Czjzek).	One	"
Truncatulina lobatula (Walker & Jacob).	Common	Not Rare
" variabilis d' Orbigny.	" (but less than T. loba-	
" wuellerstorfi (Schwager).	One [tula)	Absent.

RUFUS M. BAGG, JR.

MEETING OF SECTION A OF THE AMERICAN PALAEONTOLOGICAL SOCIETY.—The vertebrate palaeontologists had an interesting meeting at Philadelphia during Convocation week. Prof. Henry F. Osborn presided. At the close of the meeting Prof. W. B. Scott was elected president and Marcus S. Farr, secretary, for the coming year. In all eighteen papers were presented. The three sessions held did not furnish time for the reading of all these. President Osborn delivered the annual address on "Ten years' progress in Mammalian Palaeontology." This is to be published in full. The last session was occupied in a discussion on the phylogeny and classification of the reptiles. Prof. Osborn opened with a general review of the subject, pointing out the gradual development of the idea of a double grouping of the reptiles, beginning with Baur's phylogeny published in 1889 and continued in the discussions of Cope, Woodward, Broom, Noposa, Williston, Boulenger, Osborn and McGregor. Prof. Osborn stated that the chief difference among writers related to the position of the Ichthyosauria, the Sauropterygia, and the Testudinata. Prof. Williston spoke especially regarding the plesiosaurs and turtles. He regarded the two groups as fundamentally different. The characters distinguishing them are as follows:

Turtles.	*Plesiosaurs.*
Vomer unpaired.	Paired vomers.
No posterior parasphenoidal process.	A separate parasphenoid.
Opisthotic separate.	Opisthotic not separate.
Cervical vertebrae eight.	Cervicals from thirteen to seventy-six.
Ribs intercentral in attachment.	Ribs diapophysial in attachment.
Ten dorsal vertebrae.	Twenty dorsals.

Dr. J. H. McGregor maintained that the Ichthyosauria belong to the Diapsida and that the closed condition of the temporal roof is secondary in nature. Dr. O. P. Hay showed that the original condition of the temporal region was a covered one, as shown by the skulls of the primitive Amphichelydia, all the older genera of turtles, and the lower families of living turtles. The roof has become reduced through excision from behind in most cases; from below, in others. There has never been any true supratemporal fossa. The turtles have been derived from the Cotylosauria, possibly through the Chelydosauria. He maintained that the turtles and the plesiosaurs are so different that they belong to different subclasses.

A paper was read for Dr. F. B. Loomis on "The Amherst college expedition to the Wasatch and Wind river basins in 1904." New localities for vertebrate fossils were found and some interesting forms were obtained. Mr. O. A. Petersen reported on some investigations in the region where Daemonelix is found. He concludes that the fossil is the burrow of the rodent Steneofiber. Mr. Earl Douglass sent a paper and drawings describing a monotreme-like mammal from the White River beds of Montana. Prof. W. B. Scott gave a most interesting talk on South American ungulates. He presented a classification of the Notungulata and gave the characters of the divisions. None of these ungulates possessed horns.

Dr. O. P. Hay presented a paper entitled "On the group of fossil turtles known as the Amphichelydia." This was based on a fine skeleton of *Compsemys plicatula* from the Jurassic of Wyoming and several good skeletons of Baena from the Bridger beds. This group, founded by Lydekker, is thoroughly established. There can be no doubt that it gave origin to the Cryptodira and the Pleurodira. Extremely interesting papers were read by Dr. Wm. Patten and Mr. W. J. Sinclair, the former on "The structure of the Ostracoderms," the latter on "The Marsupials of the Santa Cruz formation." Dr. Patten exhibited a splendid collection of specimens of Bothriolepis. Dr. M. S. Farr reported on the discovery of many mammals in the Fort Union beds of Montana. Prof. S. W. Williston reported on an important locality for Triassic vertebrates near Lander, Wyoming. Many fine remains of labyrinthodonts were obtained; also of dicynodonts, hitherto not found in America; four skulls of phytosaurs; and other remains not yet determined.

Dr. E. C. Case read a paper entitled "Characters of the Chelydosauria." He has discovered that Cope's genus Diadectes really

belongs to the Chelydosauria, and a fine skull enables him to show that the group possessed many of the characters of turtles. Dr. Case is convinced that the turtles originated through this order of reptiles. Dr. W. D. Matthew described a new insectivore from the Bridger beds of Wyoming. The teeth resemble those of the most primitive creodonts, the skull is most like that of the Centetidae, the limbs are specialized for digging, and the tail is long and very massive. This insectivore belongs to the genus Pantolestes. Dr. R. S. Lull read an interesting paper on "Footprint interpretation." He has been able to correlate some of the tracks found in the Connecticut river valley with dinosaurs known from their skeletons. Dr. C. R. Eastman sent two papers "Fossil bird remains from Armissan," and "Anaximandar, the earliest precursor of Darwin."

Mr. Barnum Brown gave an account of the exploration of a Pleistocene fissure in northern Arkansas, from which he has taken nearly two thousand identifiable bones. Most of these belonged to small animals, many weasels and animals which had been dragged into the fissure by these weasels. Remains of some of the larger animals also occurred, such as saber-toothed tigers, deer, hogs, the musk ox, etc. Although many of the fossil species cannot be separated from living forms the large number of extinct species places the age of this fauna at some time prior to the middle Pleistocene. O. P HAY.

A REFRENCE LIBRARY. —I have a number of books on American geology, chiefly official reports of State and National surveys, of which no use is now made because my needs are met by the library of the United States Geological Survey. These I should like to place in some institution where they will be of practical service. For particulars address, G. K. Gilbert, U. S. Geological Survey, Washington, D. C.

PERSONAL AND SCIENTIFIC NEWS.

THE GNEISS OF THE PYRENEES. According to J. Roussel (Bull. Geol. Soc. France, 4th ser., 4th vol., pp. 380-386. 1904) the gneiss in all its exposures is in the form of lenticular masses, which shows that it does not exist everywhere at the base of the sedimentary rocks. In places it gives way suddenly to crystalline schists.

The great masses of gneiss present all the characters of typical gneiss. It is gray; its mica is white or black, and always more or less clearly disposed along parallel surfaces, these surfaces being wavy or lumpy by the formation of crystals of feldspar or of quartz. The parallelism of the

mica is not the only character of this gneiss. It is, furthermore, clearly divided into strata more or less thick which differ amongst themselves by their coarseness of grain, their richness in mica, the development more or less complete of crystallinity, the presence or absence of lenticular crystals of feldspar, the presence or absence of foreign elements, etc.

This division into strata is everywhere very distinct in the lower, hence the older, portion of the formation.

In the upper part the parallelism of the mica is less evident, the gneiss passes into granite, to granulyte and to pegmatyte; and in certain parts of the Archean sheets of granite, of granulyte and especially of pegmatyte, alternate with crystalline schists. These latter are ordinarily glittering, satiny or sericitic, with scales of white mica visible to the naked eye or under the loup. They are almost everywhere rich in minerals, and in certain cases they contain grains of quartz and thus pass to mica schist. Everywhere the true mica schists occur only exceptionally in the Pyrenees, whether in the region of the gneiss or in that of the crystalline schists.

Observation shows that at all horizons of the formation of the gneiss are certain rare lentilles of crystalline talcose, chloritic or amphibolitic schists or of calcareous cipolins.

Not only do we see in the upper portion crystalline schists alternating with gneiss, but in the mass of the gneiss itself can be seen inclusions of schists not completely digested.

Everywhere the gneiss is in the form of lenticular masses: everywhere it terminates as a wedge in the schists. At the points where it ends thus it can be seen to alternate sveral times with the crystalline schists, which on one side penetrate into the mass of the gneiss, while on the other it penetrates into the schists. This can be observed in all the exposures, but principally in the high valley of the Soulcen, one of the sources of the Vicdessos.

All these facts prove that the gneisses and the schists of the Pyrenees are synchronous.

The geological map shows that the gneiss appears in the same places as the granite, although the two rocks do not mutually interpenetrate. They are both confined principally to that central ridge already mentioned and which occupies of itself a fifth part of the mountain chain. This ridge is replaced in the eastern part of the Pyrenees by the folds of the Canigau, Raz-Mouchet and Albère; and it is these then that alternate with the gneiss. Another place where the gneiss and the granite appear is in those ridges in

whose eastern end has been faulted and tilted northward. The facts presented in this rather limited area apply to the remarkable series of north and south valleys filled with alluvial and supposedly lacustrine sediments found throughout the mountainous region of Montana. *W. H. Weed.*

CELESTITE-BEARING ROCKS—A study of the rocks—shales and dolomitic limestones—of the upper portion of the Salina epoch in central New York shows that celestite occurs quite widely disseminated throughout them (1) in the form of well developed crystals and (2) in small circular spots. The celestite was no doubt deposited simultaneously with the rock material. The rocks on the Island of Put-In-bay, lake Erie, and in southern Michigan, especially those at the Maybee quarry, Monroe Co., show a similar occurrence of celestite. When celestite bearing rocks are leached by the action of circulating water the celestite passes quite readily into solution and the rock then assumes a porous character; in this manner the so-called "vermicular limestones" of New York and also the "gashed" and "acicular" dolomytes of Michigan may be explained. *E. H. Kraus.*

ADDITIONAL AWARDS TO THE GEOLOGICAL SURVEYS EXHIBITING PUBLICATIONS AT THE WORLD'S FAIR, ST. LOUIS, MO.

Grand Prizes were Awarded to the Following:

The Geological Survey of India.
The Geological Survey of France.
The Geological Survey of Mexico.
The Seismological Survey of Japan.

Silver Medals were Awarded the Following

The Geological Survey of Louisiana.
The University of Texas Mineral Survey.
University Geological Survey of Kansas.
The Geological Survey of Wyoming.

The exhibit of the geological survey of North Carolina was not eligible for an award on account of the fact that the geologist in charge of that survey was also chief of the Department of Mines and Metallurgy at the Exposition, and a member of the superior jury granting the awards.

J. B. Hatcher

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JOHN BELL HATCHER.*

CHARLES SCHUCHERT, New Haven, Conn.

PORTRAIT PLATE XI.

The daily morning papers of July 5, 1904, announced the death, on July 3, of one of America's most distinguished paleontologists, John Bell Hatcher. Early in June he was in Washington and in New Haven, studying the Ceratopsia of the National and Yale University museums. While with the writer at that time he more than once complained of being tired, somewhat listless, and ill, but these feelings were ascribed to overwork. He returned home full of plans for the future, including another trip to Patagonia, little thinking that he was then doomed. His vitality had been severely taxed in Patagonia, and this combined with the strenuous nature of his entire life made him physically unable to withstand an attack of typhoid fever, the presence of which had not been determined until a week or ten days before he died. His death is all the more keenly felt because he was less than 43 years of age, and because it followed so soon after the demise of another distinguished paleontologist, Charles E. Beecher.

John Bell Hatcher, the son of John and Margaret C. Hatcher of Virginia, was born at Cooperstown, Brown county, Illinois, October 11, 1861. His parents removed to Greene county, Iowa, when he was very young. In his childhood he was not strong and received his early education from his father, who in the winter months combined

* Sketches of Hatcher have appeared as follows: WM. B. SCOTT, *Science*, July 29, 1904, pp. 139-142. W. J. HOLLAND, *Annals Carnegie Museum*, II, 1904, pp. 597-604, portrait. GEORGE F. EATON, *Amer. Jour. Sci.*, August, 1904, pp. 163-4. W. J. HOLLAND, *Geol. Mag.*, London, Nov., 1904, pp. 568-573.

teaching in the schools with the labor of his farm. As a boy he grew stronger and worked as a coal miner; from the income thus received he saved sufficient money to enable him to go to college. In 1880, he entered Grinnell College, Iowa, but soon left for Yale University, where in 1884 he was graduated from the Sheffield Scientific School. When a coal-miner his attention had been directed to geology and paleontology, and he then made a small collection of Carboniferous fossils. These he brought to New Haven and showed to professor Brush, who later introduced him to professor Marsh, and thus was started his career in paleontology. He impressed upon Marsh that he wanted to collect and study fossils, and that he was willing to work at almost any salary.

The graduating exercises hardly over, Hatcher started on a collecting tour for Marsh, June 25, 1884, for Long Island, Kansas, where he was for a time associated with Mr. Charles H. Sternberg. After a month's apprenticeship he began to collect independently and soon became the foremost collector of fossil vertebrates in this country. While with Marsh, from 1884 to 1893, nearly all his time was devoted to collecting. In 1884, he was in Kansas until late in November, then spent the winter months until the latter part of March around Wichita Falls, Texas, collecting Permian reptiles. Most of the year 1885 was spent in a second tour about Long Island, Kansas. In 1886, he collected in the Pliocene and Oligocene formations, mostly near Chadron, Nebraska, sending to Yale carloads of material from the Brontotherium beds. This was his first great year as a collector and ever afterward new and fine specimens of mammals and reptiles came in in a steady stream. It will be many years before all these collections are worked out.

It is probable that, owing to the strenuous way in which Hatcher worked in the field, his great summer's toil of 1886 taxed his strength too severely, for much of the winter of 1886-87 he lay in the hospital at New Haven suffering from inflammatory rheumatism. However, early in March, 1887, he was again back at Chadron for more *Brontotherium* material. During the late autumn and winter,

months he collected in the older Mesozoic deposits around Washington, D. C., Richmond, Va., and in North Carolina. The age of these beds had heretofore not been satisfactorily determined, but here as elsewhere Hatcher was successful in securing near Washington considerable dinosaur material, which thus enabled Marsh to prove the presence in this region of the Upper Jurassic formation. In 1888 he was again at Long Pine and Chadron, but also investigated new regions—the Judith river of Montana and Hermosa, South Dakota. In the spring of 1889 he discovered the first *Triceratops*, near Lusk, Wyoming, and continued to exhume these large and remarkable dinosaurs until 1892. During this time he took up not less than 50 individuals of Ceratopsia, 33 of which had more or less perfect skulls; also parts of ten or more and two remarkably complete skeletons of *Claosaurus* now mounted in high relief—one at the U. S. National Museum, the other at Yale. During this period, also, he collected in a new and novel way many Laramie mammals from ant hills. To secure these small remains, one man would hold a bag while another would throw into it rapidly several shovelfulls of the "mammal sand," leaving the bag until the next day, when all the ants would be found to have crawled out of the dirt.

When with Marsh at New Haven, Hatcher's time was devoted to the preparation and study of the fossils he had collected, and to familiarizing himself with them as an aid to further field work. From 1884 to 1892 he sent in nearly 900 boxes of vertebrate material. As a rule, these boxes were of large size, and one exceeded three tons in weight. This huge box (about 10 feet long, 5 feet wide and 6 feet deep) contained the largest known skull of *Triceratops*, had to be lifted out of a ravine fifty feet deep, and hauled to the railroad over a trackless country and through streams for more than forty miles. It is no exaggeration to state that during the 20 years of Hatcher's paleontological activity, he with the assistance of a few field helpers sent to the U. S. National Museum, and to Yale, Princeton, and Carnegie museums, not less than 1500 boxes of fossils. This is a record that will stand unequaled, a work that Hatcher loved, resulting in material part of which he hoped it would

be his lot to study. After Marsh's death the uncompleted Ceratopsia volume was assigned to Hatcher by the U. S. Geological Survey. This gave him much gratification, for he was thus enabled to associate his name, not only as a collector, but also as a student, with these great and curious beasts, all of which he had discovered and taken up. In this work again was shown his unbounded enthusiasm and strenuosity, as nearly all the liberal financial allotment from the U. S. Geological Survey was spent by him on preparators, draughtsmen, and clerks. Not more than a few hundred dollars remained for his own services, but at any cost the volume must be completed by July 1, 1904, and this would have been accomplished had not sickness overtaken him. However, it is a source of great satisfaction to his friends that he left the manuscript and drawings for this large volume nearly finished.

Of his unequaled ability in the field, Scott has said: "Hatcher had a positive genius for that particular kind of work. * * * Marvelous powers of vision, at once telescopic and microscopic, a dauntless energy and fertility of resource that laughed all obstacles to scorn. * * * He may be said to have fairly revolutionized the methods of collecting vertebrate fossils, a work which before his time had been almost wholly in the hands of untrained and unskilled men, but which he converted into a fine art."

In the spring of 1893 Hatcher accepted a call to Princeton University as curator of vertebrate paleontology and assistant in geology. Of his career at Princeton Scott has stated: He "at once threw himself into his new duties with characteristic ardor. For the three summers of 1893-5 he conducted field-parties of students through large parts of Utah, Wyoming and South Dakota and, with all of his old interest and skill, gathered priceless collections of mammals from the Uinta, White River, Loup Fork and Sheridan beds, accomplishing wonders, in spite of scanty resources which sadly hampered his plans. His students became his enthusiastic friends and admirers, glorying in the courage and devotion which overcame every obstacle, material or moral. In return, Hatcher took the warmest interest in his students, especially in those who were

struggling against difficulties to secure an education; in the quietest and most unostentatious way he was continually devising effective means to help such students to help themselves and thus enabled them to continue their studies without any impairment of their self-respect.

"The most important work which Hatcher undertook during his connection with Princeton was his exploration of Patagonia in the years 1896 to 1899. The plan was all his own and was not proposed to the geological department until everything was nearly ripe for action; he secured the greater part of the necessary funds and, with characteristic generosity, was himself a liberal contributor. How successful this great undertaking was is very generally known. * * *

"The principal object of the expeditions was to gather the most extensive possible series of the fossil mammals for which Patagonia has been so famous since the days of Darwin's 'Voyage of the Beagle,' and next to determine the stratigraphical succession of the beds in which these fossils occur. This involved extensive explorations of regions where no white man had ever been before and brought to light much geographical information. At the same time, the plants and recent animals were collected, so far as it was possible to do so without sacrificing the principal end in view, and in these departments also an unexpected measure of success was attained, and a representative series illustrating the botany, zoology and paleontology of Patagonia was secured.

"Hatcher then conceived the plan of publishing together in one uniform series of reports, by the hands of different specialists, all these results, which would otherwise necessarily appear in separate form, scattered throughout the various technical journals. This plan was submitted to Mr. J. Pierpont Morgan, and to his liberality it is due that this cherished scheme is now in process of realization and in a manner surpassing the hopes of its original proposer. * * * He [Hatcher] has raised for himself an enduring monument in these volumes, which owe their existence to him, however much or little may be his verbal contribution to their contents."

On February 1, 1900, Hatcher accepted the position of curator of paleontology and osteology in the Museum of the Carnegie Institute, Pittsburg, Pennsylvania. Here he had the generous support of the founder of the museum, and for four summers carried on explorations in the western states. Most of his papers were written while at Pittsburg, and one of the best is the description of *Diplodocus carnegii*. It is Mr. Andrew Carnegie's wish that a life-size reproduction of this animal, based on the Pittsburg specimen, be presented to the British Museum of Natural History. During the 18 months previous to last July, Hatcher had been supervising the making and mounting of this great restoration, which was completed while he lay on his sick bed.

Of Hatcher's expeditions into the western regions he wrote no narrative, but of his great expedition into Patagonia he, in 1903, presented a splendid and most interesting quarto volume of 314 pages. This monumental work, entitled "Narrative and Geography," is inscribed to the man that found Hatcher, in the following simple words: "To the memory of Othniel Charles Marsh, student and lover of nature, this volume is dedicated by the author." Of this volume Dr. Dall, himself an early explorer in similar lands in Arctic regions, has given a splendid summary, quotations from which are here given:

"About half the total area of the region consists of vast terraced plains intersected by river cañyons and of a subarid character, which, in the central portion, have been overflowed by lava beds covering hundreds of square miles. To the westward, out of a very mountainous region, rises the Andean range, cut here and there by rivers which rise in lakes on its eastern side.

"At the base of the Andean mountains the Patagonian plains have an altitude of 3,000 feet, and slope very gently to the eastward. About fifty miles from the Atlantic coast they descend more rapidly by a series of terraces or escarpments which face to the eastward. The lowest of these has an average altitude of 350 feet and terminates in abrupt cliffs which, for a thousand miles, constitute the margin of the land, except for a narrow beach at the base, which,

at high water, is covered by the sea or drenched with the spray of a perpetual and tremendous surf.

"Scanty grasses with stunted shrubbery in occasional patches are characteristic of these vast and silent stretches, redolent of loneliness which grips the imagination.

"In the narrow canyons, or by the rivers in broad valleys of erosion, the traveler may come upon green spaces where the vegetation breaks into a joyous luxuriance, where birds abound, and deer and other animals meet man with fearless curiosity. Here the eye may search in vain for a limit to a basaltic desert extending in flat and stern monotony for leagues beyond the visible horizon. There some broad salt pan with deceptive mirage mimics the prehistoric lake of which it forms the dregs. At times wrapped in gloomy fogs or swept by tempests of incredible violence; fronting the towering Atlantic surges with unshaken cliffs and serrate talus, looking out to shifting bars of sand, the terror of the navigator; a vast cemetery for ghostly herds upon the like of which alive no man has ever gazed; it is a strange, silent, bitter, lonely land.

"How our author went out into it, what he met, and how he fared, are told in modest yet most interesting fashion in this stately quarto. His story is so interesting and the unpretentious courage of the narrator so evident, the spirit of the land and its mysterious fascination so fully expressed, that few will close the book without a regret that it can not reach a wider audience. It is really too good to be reserved for the readers of quartos.

"The volume is so full of scientific meat that it is difficult to make a satisfactory abstract, and impossible to condense it within the limits of such a review as this. There is something for every taste. The life of bird and beast; the phases and contrasts of vegetation; the life of the Tehuelche Indians and the waifs who have cast civilization aside like a garment, at the call of the wild; the topography and geology; and mingled with it all a flavor of real North American character to which something in each reader's soul will leap with sympathy and admiration."

In character Hatcher was a very plain, unassuming, hard working, resourceful man,—honest, devoted, fearless,

determined, and strenuous to a remarkable degree. He hated pretense of any sort. He possessed a singularly original and independent mind and the keenest powers of observation.

Hatcher was 32 years of age when his first paper was published, and during the last ten years of his life he wrote 46 articles, the largest of which is the "Narrative and Geography" of Patagonia. In manuscript he has another large volume—"A monograph of the Ceratopsia"—nearly completed. There is considerable variety in his work, as may be seen from the following summary: 25 papers are paleontologic, 16 stratigraphic, 4 physiographic, 1 ethnologic, and 1 a narrative.

While Hatcher is famous as a collector of vertebrate fossils and as a Patagonian explorer, he also stands among the leaders of vertebrate paleontologists. His biologic work is that of a careful osteologist, never going deeply into morphology. He likewise attained pre-eminence as a stratigraphic vertebrate paleontologist. During the past twenty years he entered the field each year for many months at a time, and saw more varied stratigraphy and collected more vertebrate remains than any other man. Outside of the Triassic and the Lower Cretaceous, he had studied all the formations of the Mesozoic and Cenozoic of the great West. This knowledge was to bear fruit in the coming years, as he had agreed to cast in his lot with the U. S. National Museum and to take advantage of the splendid opportunities for consultation with the many active geologists and paleontologists of the U. S. Geological Survey. His greatest days were to come, and four museums were to reap the harvests of his stratigraphic knowledge and thus to place vertebrate paleontology upon a sounder chronologic basis. "Hatcher was cut off just when his powers and opportunities had reached their fullest development and the boundless field, in which he so loved to work, lay open and unrestricted before him." (Scott).

In 1887, he married Miss Anna M. Peterson, who with four children survives him.

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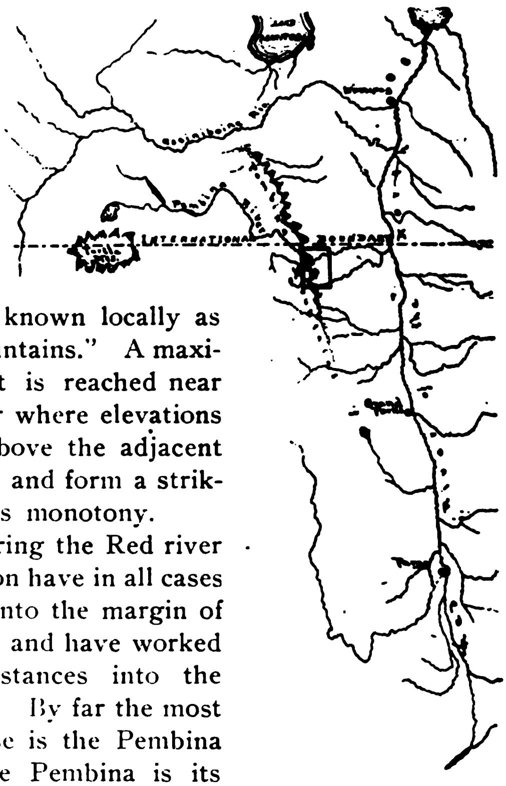
ECONOMIC GEOLOGY OF THE PEMBINA REGION OF NORTH DAKOTA.

BY CHARLES P. BERKEY, New York City.

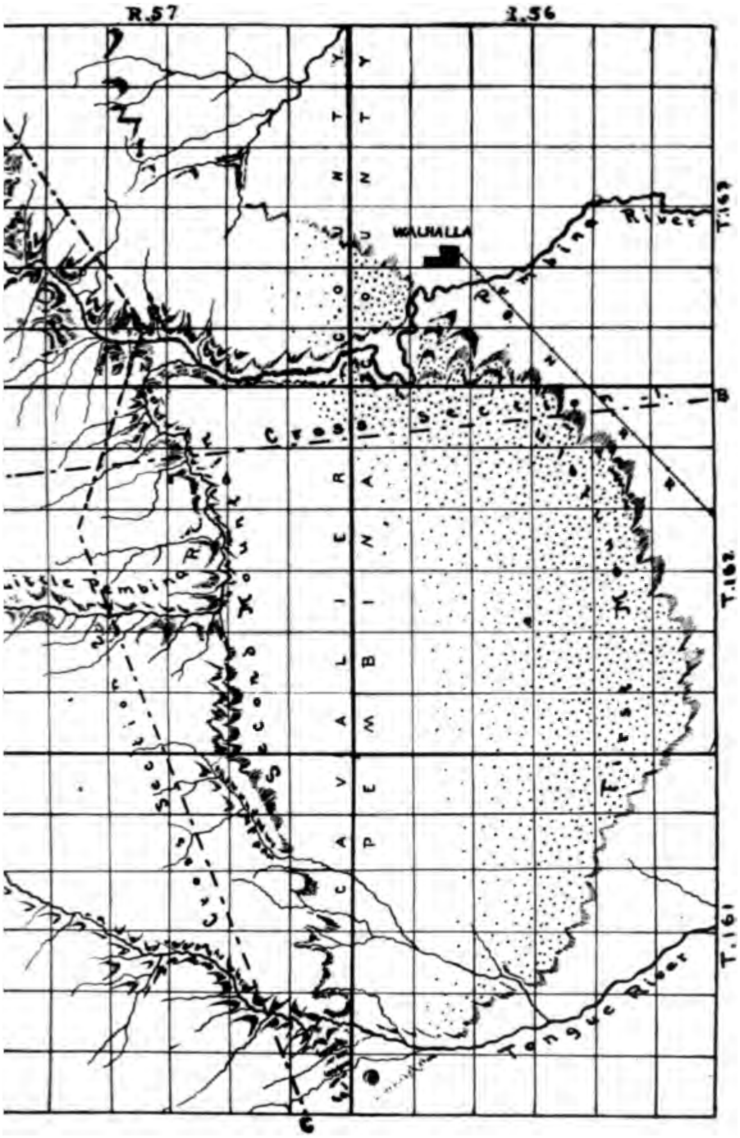
PLATE XII.



Prominent escarpments form the western margin of the Red river valley in the vicinity of the international boundary, in both N. Dakota and Manitoba. These are known locally as the "Pembina mountains." A maximum development is reached near the Pembina river where elevations of 600-700 feet above the adjacent plain are common and form a striking relief from its monotony.

Streams entering the Red river valley in this region have in all cases cut deep gorges into the margin of these escarpments and have worked back variable distances into the highlands beyond. By far the most important of these is the Pembina river. The Little Pembina is its main tributary and this together with the Tongue river 10 miles farther south completes the list of streams to which frequent reference will be made.

The Pembina has cut a gorge 500 feet deep and half a mile wide. Relief resulting from the work of this river and its tributaries forms the most prominent physiographic feature of Cavalier county, North Dakota. At many places along the gorges the bluffs are bold and bare exposing all rock formations in detail. At all other points a moderate covering of glacial drift and soil conceals the underlying rocks. The covering is seldom more than 20 to 30 feet thick on the highland country. In places large granite



Map of the Pembina region, North Dakota. The stippled area is delta deposit. To the west of this deposit the underlying formations are Cretaceous shales; to the east are the typical silts of the Red River Valley. See cross sections, Figs. 1 and 2.]

boulders are an abundant constituent, contrasting strongly with the clayey local facies or the still less common gravel, sand, and clay mixture. As a rule the soils are very clayey.

Structure af the Escarpments—There are two escarpments, one behind the other, in the Pembina region. The lower one is known as the "first mountain" and is best developed in the vicinity of Walhalla, North Dakota, where the Pembina river debouches upon the plain of the Red river valley. Here there is a shelf 5 or 6 miles wide, 200 feet above the plain at its outer margin, which gradually rises toward the west through 100 feet or more to the foot of a second escarpment known as the "second mountain." At this point another ascent of 200 to 300 feet reaches the general level of the highland country which ascends slowly toward the Turtle mountains beyond. The entire margin of this area was described by Mr. Upham* in his study of lake Agassiz. The "first mountain" noted above is Mr. Upham's Pembina delta deposit. The whole shelf was considered by him of this origin and separated from the shales below by a sheet of till.

As will be seen from the accompanying map, the Little Pembina river after leaving the higher plateau runs along the base of the second escarpment to its junction with the main stream. Great quantities of boulders and some till have slid into this part of the gorge as undercutting of the bluffs has proceeded. The presence of such material in this transverse gorge led as the writer believes to an erroneous idea of the true structure of the whole first mountain.

Ordinarily the weathering process is so uniform on the soft formations of the bluffs and the creep of the clays so gradual that none of the real ledges might be seen on the east side. But the past season has been excessively wet. The severe rain storms started numerous land slides, uncovering many points that had formerly been completely covered with mixed residuary and alluvial accumulations. A recent examination therefore made clear that Cretaceous shales occur to within 15 or 20 feet of the top of the bluffs on both sides of the Little Pembina to its mouth. The same is true of the Pembina from this point still farther east for probably two miles. The capping of the shelf

* U. S. G. S., Monograph xxv. p. 187.

through which this stream runs at this point is a very stony drift and it is certainly from this deposit that the boulders lying down in the gorge were derived as residuary matter. This same relation was observed on one of the tributaries of the Tongue river 15 miles farther south.

About half way across the shelf however conditions change. Original Cretaceous beds are replaced gradually by granular assorted and roughly bedded deposits that are no doubt of delta origin. On the shelf itself along this outer marginal half there is more porosity and sandiness of subsoil as noted in the farm lands and the wells are very deep compared with those situated on the inner half of the mountain. One half of the total area is therefore no doubt a delta deposit.

The accompanying figure representing a section of the two mountains and crossing the transverse portion of the Little Pembina, is in accord with the above conclusions.

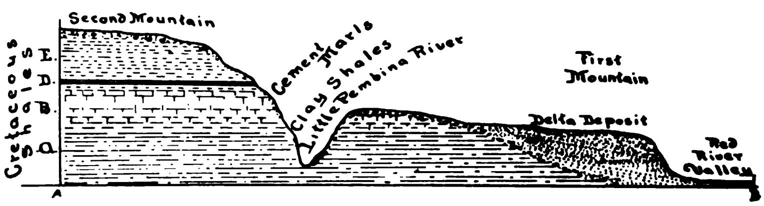


Fig. 1. Section across the Pembina Delta, showing the subdivision of the Cretaceous shales and the extent of the delta deposit.

Some portions of the delta deposit and accompanying drift have economic value. There are excellent gravels and in some places the assorted granular clays are workable. The Cretaceous shales themselves however are so near by, and are so much more uniform, and are of so much greater range of use that the delta deposits have little interest from that standpoint.

Cretaceous Shales.—The main body of the Pembina mountains is made up of Cretaceous shales. They underlie the delta deposit of "first mountain" and the Red river valley, in part, and they continue westward across the whole state of North Dakota.

In color the shales vary from cream-white through yellow and blue and green to brown and even black. Cream-white, bluish gray, greenish gray, and black colors are

characteristic of continuous beds. Yellowish color is local and best developed where conditions are favorable to weathering and leaching action, while the brown facies is in all cases due to staining of iron oxides formed in the decay of iron pyrite.

In physical characters all are moderately soft earthy shales. The sediments of which they are formed are of very fine grain and remarkably uniform. There is an occasional concretion of lime or iron sulphide, or a septarian nodule, or a selenite crystal or even a thin slab of lime stone, but these are confined to a few horizons and are insignificant in comparison to the great mass of shales exposed. There is occasional faulting on a very small scale. There is local leaching and a little chemical modification, but the changes are slight.

Petrographically they vary from black carbonaceous shales to white alum shales, and from bluish gray or yellow marls to bluish green or greenish black clay shales. Calcite, pyrite, selenite, and limonite are secondary minerals of most prominence in the formation as a whole.

Chemically the beds vary greatly. Lime, iron, and carbonaceous matter are the chief disturbing factors. One small seam of coal a fraction of an inch thick has been seen, but in general the carbonaceous content is not high in the regular shales. Lime however is important ranging in the various beds from a fraction of one per cent to extreme values of over 70 per cent in the form of carbonate. Iron is as a rule more prominent in the non-calcareous beds. This interchange of predominance becomes an important factor in fixing the possible uses to which these clays may be put.

Sub-divisions.—There are few sharp lines of distinction between the successive beds. Even where chemical analysis shows radical differences, the formations sometimes present a most deceptive uniformity to the eye. Combining, however, such physical breaks as are apparent with the chemical differences that are known, the following general succession is characteristic and can be identified throughout the district:

E. Black and grayish brittle shales that break out in chips or in thin laminae like paper shales. Where carbonaceous matter is

prominent they are very black in color. Iron is a constant impurity, and brown or yellow staining of surfaces and veinlets or fissures following water seepage, is a noticeable effect.

Thickness........300 feet+

D. A series of 10 alternating black and white bands, the thickest being about 6 inches. The black bands are carbonaceous while the white ones are siliceous but not gritty and have a decided alum taste. The contrast between these two types is very striking and their persistence throughout the Pembina mountain district makes them a good datum horizon.

Thickness........6 feet.

C. A bed of dark shale heavily stained with iron and carrying locally excessive quantities of gypsum. Lies just below the black and white series and in places its firmness causes a shelf-like break in the bluffs where this bed is exposed.

Thickness........4 feet.

B. Yellowish or bluish-gray massive limy shales or marls, carrying 20-70 per cent calcium carbonate in their composition. They are not uniform throughout their whole thickness, but are resolvable into a series of beds depending upon the lime content for their distinction. They are more massive and block-like in their habit and more uniform in their appearance than any other beds of this area. They are locally called "cement beds."

Thickness.........150 feet±

A. Greenish and grayish black laminated shales weathering into plastic clays. They are low in lime to a limit of less than one per cent. The change from the next overlying beds to this is gradual and is marked by the change to low lime content. No sharp line can be drawn. There are occasional horizons of concretions, septerian nodules and gypsum crystals.

Thickness........250 feet.+

The above series of beds forming the Pembina mountains are supposed to correspond to the different subdivisions of the Cretaceous recognized by Babcock* as follows:

E.—300 ft. black and gray shales.—Pierre.

D.—6 ft. black and white bands.

C.—4 ft. iron and gypsum bed.

B.—150 ft. blue and yellow marls.—Niobrara.

A.—250 ft. greenish and black clay shales.—Benton.

Fossils are rare in these shales. A few traces are seen in the Pierre (E) but none were identified. None at all were in either D or C.

But in B, and in the talus clays and marls along the

**First Biennial Report, Geological Survey of North Dakota, 1891,* E. J. BABCOCK, pp. 18-23.

weathered bluffs where B is exposed, a few good fossils typical of the Niobrara have been found by the writer. *Ostrea congesta* Conrad, is the most common. Fragments of a large shell of fibrous structure and prominent parallel ridging are also common; they probably belong to *Inoceramus platinus* Logan. In one case a fragment of this form was found replaced by iron pyrite perfectly preserving the structure.

The mosasaurs are also represented. One fragment of a lower jaw carrying four teeth and a couple of vertebra were found at the Mayo location. A large fish vertebra and the fore part of the upper jaw carrying stubs of teeth were found at the same place. They belong to the Portheus of Cope. Together the few forms found serve to determine the age of these marl beds as Niobrara. At Tongue river both fish and mososaur remains fairly complete have been reported from the cement bed.

No fossils have been observed in the shale beds of division A, here credited to the Benton formation.

The eastern edges of these formations are exposed in the stream gorges of the "second Pembina mountain." Rarely can all be seen at any one point, but this portion of the Cretaceus series is readily made out and followed. What there is below A or above E does not appear in this area.

Local and Economic Descriptions.—The Tongue River Section.—Tongue river cuts deeply enough into the second mountain to expose all the beds down to and including the cement beds. A short distance above the entrance to this gorge where the marl zone is particularly prominent the Tongue river cement plant is situated. At this point it is about 70 feet from the bed of the creek to the base of the black and white bands of bed D above. Both D and C are in typical development, but only about 50 feet of the brittle shales of bed E are exposed because of drift and slide from the bluff.

Cement manufacture has been the chief attraction here. The plant is making a natural cement that is claimed to have unusual quality. It is certainly giving good satisfaction to local patrons. An extensive plant was installed.

Lack of direct railroad connection for shipment however is a great handicap and its operations have been intermittent as a consequence. Several years of experience on the ground also has led the company to abandon some of their earlier equipment. Burning is now done with slack coal in two open 42 foot continuous kilns. Formerly the cement rock for the works was obtained from the 70 foot face of the bluff, but this proved unsatisfactory through lack of uniformity. At the present time cement rock is mined from a 7 foot bed near the base of the bluff.

This rock is drab to grayish green in color with numerous small white specks. It is very fine grained and uniform and massive rather than shaly in habit. It breaks out in large blocks and is reasonably resistant and tough, although soft and earthy in feel and easily worked. The bed is set off sharply both above and below by bedding planes. Little timbering seems to be required and the workings are comparatively dry. The bedding is not quite horizontal. There is a slight dip toward the northeast. Besides these are two small faults with displacements of one to two feet. Joints all run E and W. and in displacements it is the eastern side that has dropped.

A complete chemical analysis of the rock at this locality is not at hand. Tests however made by the writer for compartive purposes on the lime content gave $CaCO^3$, equal to 55.13 per cent.

The Little Pembina Section.—In the Little Pembina gorge also the cement beds are cut into, and in its lower course, before joining the main Pembina river, the underlying clay shales are also uncovered. Nowhere however, is there any special quality of material or any special attractions of location to encourage development of either marls or clays. The cement bed is the same as that at Tongue river and is doubtless of similar grade. The writer has, however, carried the investigation no farther than an identification of the beds.

The Big Pembina Section.—The main Pembina river, where it emerges from the highland country of the Pembina mountains cuts 400 feet into cement marls and clay shales. By adding to this the higher beds that appear in ascending the stream a few miles as much more is found, so that the

whole series represented in the dissection of the second mountain may be tabulated as follows:

Glacial drift, variable in thickness and character		0-25	ft.
Cretaceous Shales	Gray to black brittle shales	300	ft.
	Black and white bands	6	ft.
	Brown iron and gypsum bed	4	ft.
	Yellow and bluish massive marls	150	ft.
	Black and greenish gray laminated clay shales	250	ft.

Of these the last two are of special interest because of their economic promise. By far the best outcrops of these are in the north bluff of the river just opposite the mouth of Little Pembina in sections 33 and 34, T. 163, R. 57, Cavalier Co., N. D. This locality has many other advantageous features that scarcely come within the province of a geologic paper, such as feasability of railway connections, the proximity to a local wood supply, and the possibility of securing abundant water power by a dam across the river. At this point glacial and pre-glacial erosion has removed the upper beds of the series, as outlined above, leaving only the two lower members, i. e., 250 feet of clay shales and 100+ feet of cement marls capped directly with 10 to 20 feet of drift.

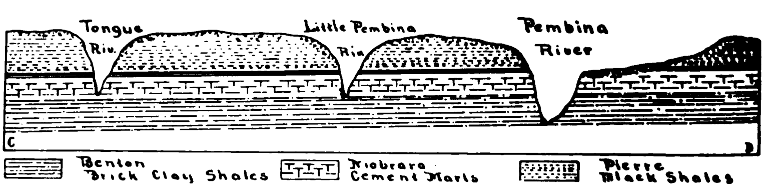
Cement Marls.—Local interest following the impetus of the Tongue river development centered in the marls at first, and these beds not only here but along the whole escarpment and river have been repeatedly tested by numerous prospectors with a view to cement manufacture. There are zones in these marls whose lime content brings them within the class of cement rock. A long series of rough tests in the field, made by the writer, with crude equipment, for the purpose of limiting the horizons, gave fairly good and decisive results. Samples were oven dried and weighed and the constituents soluble in cold dilute hydrochloric acid were dissolved out. Then the residues were burned and weighed as representing approximately the sand and clay content, while the difference in weight was taken to roughly measure the maximum possible lime content. This rapid preliminary testing proved very useful and served finally to locate shales of a quality that were not thought to exist in this region. A series of 35 samples of the marls gave a range of:

Insoluble matter (sand and clay) 25 per cent to 60 per cent.
Soluble and Volatile matter (mostly calcium carbonate) 40 per cent to 75 per cent.

The tests proved that in general the higher beds of marls were the richer in lime and that lower horizons rapidly decreased in this constituent to almost zero where the typical beds of the underlying clay shales are reached.

Nearly all of these detailed examinations were made on the Mayo property at the mouth of Little Pembina river. On the north side of the Pembina river at this point the river bluffs are 400 feet high. A section of at least 350 feet of shales are exposed. A yellowish color of the uppermost beds as they occur here is not a constant character of the same beds throughout the whole district. This color is notable only where the immediate covering is drift, and therefore porous, or along much exposed bluffs. In recently exposed beds or where there is great thickness of shale covering the color is drab or greenish gray as in the Little Pembina and Tongue river sections. It is clearly a case of bleaching or oxidation of the iron content with more or less leaching wherever water percolation is active. On the bench of land forming the inner margin of the "first mountain," drift lies directly upon the marl beds and here such bleaching has penetrated 15 to 20 feet. Seams where circulation is easiest are often red from iron stain while the interiors of larger blocks are still bluish.

In all other respects samples of the gray cement rock of Tongue river are duplicated on the Pembina. They are undoubtedly the same beds and their relationship may be seen at a glance in the accompanying figure.



[Fig. 2. Cross section of the Pembina district from north to south showing the correlation of beds exposed in the chief river gorges.]

So far as preliminary investigation may serve as indication, one would be expected to prove as valuable as the

other. A partial analysis for comparative purposes on two typical samples sent from these localities gave:

Tongue river sample—	Residue 27.9 per cent;	$CaCO^3$ 55.13 per cent.
Pembina river sample—	" 29.4 "	" 53.20 "

In each case the sample is not the maximum limit for lime content. Another sample of the Pembina locality marls gave:

Insoluble residue	14.00 per cent.
Iron and alumina	18.00 per cent.
Carbonate of lime	60.00 per cent.
Moisture	8.00 per cent.

Clay Shales.—Below the cement marls, in the Pembina section, lie a thick series of clay shale beds. They are laminated more prominently than the marls, and are very plastic on weathered outcrops. Their chemical constituents lime and iron, vary widely in different beds. This is the lowest formation exposed anywhere in the "Pembina mountain" region. Most of the rivers have not eroded deeply enough to reach it.

Partial analysis of two samples of these shales at different horizons gives the following percentages:

	No. 0.	No. 4.
Silica—SiO^2	61.03 per cent.	61.52 per cent.
Alumina—Al^2O^3	22.70 per cent.	18.65 per cent.
Iron—Fe^2O^3	6.53 per cent.	4.90 per cent.
Lime—CaO	.97 per cent.	.75 per cent.
Magnesia—MgO	.51 per cent.	1.32 per cent.
Water—H^2O	7.92 per cent.	8.80 per cent.
	99.66 per cent.	95.94 per cent.

In the above all the iron was measured as Fe^2O^3, although it is not all in that form, the column for water also includes other easily volatile constituents, and no effort was made to measure the alkalies. The analysis serve however to determine the general range of composition.

A systematic and thorough series of experimental tests have been made on these clay shales to determine their value in brick and tile manufacture. Most of them have been carried out by the writer on a laboratory scale first and then, following the lines thus indicated for a particular horizon or bed, the appropriate practical test was made by taking a suitable quantity to an operating plant willing to run the

material. This last method of proving the quality was followed in person by Mr. H. A. Mayo, of Walhalla, who was the owner of the most advantageous site where the clays are exposed. He has recently established a plant on this ground.

The clays prove to be especially suitable for the manufacture of drain tile, hollow block, common auger machine brick and pressed brick. Of pressed brick many varieties have been made by using different beds or different mixtures of beds. Normally the clays burn either red or cream colored depending upon the lime content of the horizon, and both of these give good background for variation. By mixing the two in granulated condition, as received from the dry pan, a most attractive natural red and white mottled effect is produced.

The usefulness of drain tile for the peculiar valley conditions is just beginning to prove itself. Trial tests of farm drainage with tile last year are altogether encouraging. Because of the rigors of the climate, together with the substantial prosperity of the country, building materials of the best grade are always in demand.

The proximity of this deposit to the Red river valley where brick clays of good quality are rare, and where structural materials of all kinds must be brought from the outside at high prices, makes it of great economic importance.

PROF. HULL'S "SUBOCEANIC TERRACES AND RIVER VALLEYS OFF THE COAST OF EUROPE."

(Reviewed by J. W. SPENCER.)

We are indebted to Prof. Edward Hull of London for his extensive investigations of the river-like valleys and canyons incising the continental shelf and the continental slope on the eastern side of the Atlantic; thus bringing into prominence the submarine physiographic characters which had been hitherto largely overlooked. These studies appear in a series, under suitable titles* which if assembled

* "Another Possible Cause of the Glacial Epoch," by Prof. Ed. Hull, LL. D. F. R. S., *Victoria Institute*, London, 1898, pp. 20. "Submerged Terraces and River Valleys bordering the British Isles," *Ib.* vol. xxx, (1897; pp. 305-324); "Suboceanic Terraces and River Valleys off the Western Coast of Europe," *Ib.* author's copy (1899) pp. 20;" * * * Off the West African Continent and of the Mediterranean Basin," *Ib* (1900), pp. 18; "The Physical History of the Norwegian Fjords" Ib. (1902), pp 26. "Suboceanic Physical Features off the Coast of Western Europe, including France, Spain and Portugal," *Geog. Jour.* (1899), pp. 10. Also in *Trans. Manchester Geological Society*, pp. 313-328, vol. xxvi, 1899.

would make a large brochure. From these, we learn of a vast number of valleys and systems of valleys indenting the continental shelf and forming submarine topographic features resembling those produced by atmospheric agents, such as are found on the American side of the Atlantic and in the West Indies. The shelf has been more or less studied since the time of Mr. Goodwin-Austin (1849).† But Prof. Hull's valleys throw new light upon their forms and sculpture, and indeed upon the whole question of great changes of level of land and sea. He further applies these changes to one of the many consequences thereof, namely the possible cause of the glacial period. As Prof. Hull's papers are not easily accessible to many on this side of the Atlantic, a review of the leading features appearing in one of our journals will extend the knowledge of what has been done in a subject embracing one of the most wide-spread groups of physiographic phenomena, which however has attracted little attention in this country, except that of two or three of us, although these have sown seed which is bringing forth a rich harvest in the old world.

The British platform extends to Iceland and Greenland, as shown by previous investigators. "This former connection is placed beyond doubt by the character of the fauna and flora."* Dr. Alfred Wallace includes Iceland with Europe in his Palaearctic region. Prof. Newton has shown that all the mammals of Iceland, except three Arctic forms, are European. Dr. Walker's studies of the botany and entomology of Iceland also witnesses the late connection with the British islands. In Greenland some forms are European, others are American and still some are Arctic. If a biological survey suggests the extension of European life beyond the present continent, which implies an elevation of the land, then such should be indicated in the submarine topographic features now submerged, and these are Prof. Hull's studies. He says that the charts show that an elevation of 1320 feet (except in the relatively narrow trench 2000 feet deeper) would connect Iceland with Europe, but the actual altitude may have

† Q. J. G. S., vol. xxii, p. 240.

* From the chapter relating to the British platform.

reached 6000 feet. The edge of the submerged terrace (continental shelf), supporting the British Isles, is generally known as the 100-fathom line, but this is misleading as the features vary and "only by a close observance of the change of depth, as indicated by the soundings"† can the features be recognized. In front of the platform the grand escarpment or continental slope, off Britain, descends steeply 7000-8000 feet, in some cases precipitously. Off Scotland the margin of the shelf is near the 100-fathom line, but in front of the English channel, it is at a depth of 180-200 fathoms. At some points the shelf is reduced to a breadth beyond the islands of 50-70 miles, while off Porcupine bank it extends for 180 sea miles beyond the coast of Ireland, and forms a peculiar peninsula, effectively shown on his map, enclosing an embayment receiving the Shannon channel at its head. It is shown to extend to a depth of over 9000 feet. From his work on the submarine topography, it would be appropriate to name it the Hull embayment, especially as he has done much more to elucidate the phenomena than any one preceding him, and he is an Irishman, too. Also the still more remarkable embayment, of similar depth, is shown between Ireland and Rockall attaining a breadth of 125 miles. It heads in an amphitheatre or great cove in the Scotland-Faeroe ridge, where this submarine feature is crossed by the Lightning channel, which is the drowned col between this and another deep channel extending down the slope to the basin of the Norwegian sea.

The continental shelf is almost level, having been covered with water-borne sediments or earlier glacial deposits. The formation of the continental shelf by marine action on emergent lands of such plateaus as the British platform has been described by Prof. James Geikie* who also noticed "the abrupt descent from the edge of the plateau," but he does not appear to have recognized that such features must have had a terrestrial origin, as the surface is sculptured with river channels.

From the west of Ireland Hull traces the courses of

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† *Trans. Vict. Inst.* Vol. XXIV, p. 205.
* *Proc. Roy. Geog. Soc.*, 1892, p. 639, p. 644.

the Erne (a distance of about 80 land miles) and the Shannon river (for 100 miles) to the amphitheatres indenting the edge of the platform. So also the course of the sinuous channel from the Irish sea is given for a distance of 300 miles before it falls over the edge of the shelf into its canyon. It is a relatively shallow feature from 50 to 240 feet in depth. The course of the old river of the English channel is more interesting. Prof. Hull shows its course from near the straits of Dover for nearly 400 miles to "the edge of the platform. For 70 miles of its course it has been known as the Hurd deep," having a width of four to five miles, and greatest depth of 354 feet below the general level of the floor of the sea (further submerged by 216 feet). Below the deeper section the channel is less apparent, probably owing to the silting up by sediments. Hull considers that the Hurd deep portion has been kept open by tidal currents, as this is the narrowest section of the English channel north of cape de la Hague. It is cut down into solid rock and is bounded by precipitous cliffs. There are tributaries from France and England. The lower portion of the channel is again open. It abruptly merges in a canyon, with walls of rock 4,000 feet in hight, cut into the great continental declivity and shelf on which it is submerged to the depth of 100 fathoms. An adjacent and larger embayment to the east may have been the former course of the channel. After passing the edge of the shelf Prof. Hull has used only isobaths of 250 fathoms. Had he put them at 250 feet apart more detail would have been obtained. The British rivers are often flowing over refilled channels, reaching much below sea level. Prof. Hull considered the British platform to have been planed down by wave action, and subsequently depressed. He compares the features with the "drowned plains," escarpments and river valleys lying outside of the North American coast. He points out the absence of the lower terrace such as that of the Blake plateau of the American coast. Prof. Hull attributes the fashioning of "the escarpments as mainly due to wave action undermining the cliff during prolonged pauses in the process of elevation or subsequent depression." The age of the platform is assigned to the Mio-

pliocene period, which was one of great terrestrial changes of land and sea over Europe. The fashioning of the continental declivity or slope, with its channels belongs to the Pleistocene period.

While a change of level raising the sea bottom 9000 feet and sinking it again may cause some hesitation in our minds, yet the marine Tertiary beds occur to 10,000 feet in the Alps, which have received their features in post-Miocene times, according to Heins, Renevier, Baltzer, Carl Schmidt, and H. Schardt. The sea level may have been considerably lowered by the accumulation of ice in the Glacial period, or again the beds of the great oceans may have been depressed, as suggested by Prof. Suess.* Also there may have been other ways, more or less speculative altering the level of the sea as described by Prof. James Geikie. In conclusion, Hull finds the continental slope to great depths "charcterized by physical features similar to those we observe on the land and due largely to similar causes, namely, marine and atmospheric erosion." Of Prof. Hull's paper Prof. Ethridge says: "Prof. Hull's interpretation that the submerged and now submarine valleys were originally formed or fashioned through atmospheric denudation in the widest sense, prior to their submergence is fully demonstrated." "No one has hitherto applied these ocean soundings for the purpose of elucidating the past physical history of the old and new submerged land once extending far to the west or into the now depths of the Atlantic." Prof. T. Rupert Jones endorses the author and says: "Dr. E. Hull, applying the methods adopted by Dr. Spencer and other American observers, is led by careful consideration of the Admiralty charts, and with accurate reasoning on the relative depths of the water, to map out the margins of the British area before it became divided up into the existing islands. The conclusions add much to our knowledge of geographical evolution, as brought about by natural causes during immense periods of time." The 100-fathom line had been the chief datum of former workers. "The distribution of animals and plants supports the conclusions arrived at by Prof. Hull" that the recent high

* Loc. cit., p. 689.

elevation of the land to a great degree caused the Glacial period.

A sequel to this paper on submarine valleys adjacent to the British Isles is one continuing the investigations to the strait of Gibralter.

It appears that Mr. Goodwin-Austin in 1849,* showed how the British platform is covered with shingle containing littoral shells, sometimes unbroken, at depths of 80-100 fathoms, as at Little Sole and Nymph banks, (Lat. 49° Long. 10° E.), and that the platform was terminated in a steep declivity. Goodwin-Austin concluded that these shell beds formed successive margins of the Atlantic before the present submergence. In 1853, Sir H. T. de la Beche† illustrated the late expanse of the land to the 100-fathom line, and observed that its width would not be much increased if extended to the 200-fathom line. He attributed the shelf to wave action and the distributing power of the tide. These early studied features have since been recognized by several writers, but none of them have indicated the real physical base of declivity, nor the river channels reaching down to it. Prof. Hull says that "The existence of such features * * * demands the admission of stupendous changes * * * as regards elevation and depression, such as naturalists might well hesitate to accept unless demonstrated by evidence of the most convincing kind. And, for myself, I fully admit that had it not been for the clear demonstration of several American geologists, but especially by that of Prof. Spencer, that the bed of the ocean along its western margin has been worn into terraces traversed by old river channels, down to depths of several thousand feet below the present level, it would probably not have occurred to me to ascertain whether these physical features characterize the bed of the ocean along its eastern margin."

The continental platform off from France to Portugal is indicated on Dr. Stieler's Hand Atlas,‡ but there are no indications that it is trenched by river-like chan-

* "The Valleys of the English Channel" Q. J. G. S., vol. vi. (1849).
† *Geological Observer*, 2nd Ed., pp. 91-92.
‡ Pub. by Justus Perthes, Gotha, 1873.

nels. Nor are such found on the small-scaled charts of the Challenger. The recent suboceanic map by Mr. Huddleston shows the platform but not the river valleys..

The British platform continues onward and in front of Brest it is 130 miles wide. In the bay of Biscay it diminishes to 100 miles; but on the north coast of Spain, it is reduced to 20-30 miles in width. West of Portugal its breadth is generally from 30 to 40 miles. It increases southward till off cape St. Vincent it widens out into a succession of terraces. Along this coast the margin nearly coincided with the 200-fathom line.

From the English channel to Gibralter, the floor of the platform is covered with gravel, sand, clay and occasional boulders with occasional mollusk remains, while the oceanic floor is a calcareous marl. From Rockall for a distance of 2,000 miles along the coast line the g reat declivity (continental slope) is intersected with channels which cross the continental platform from the great terrestrial rivers. Such a slope has its counterpart in the borders of the raised plateau of Mexico (citing the reviewer). The gradient of the declivity varies from four to twenty-one degrees or in one case thirty-six degrees. These are the mean results for each section, yet in many cases the actual slope is made up of precipitous cliffs and gentler gradients. But fuller soundings are much to be desired to complete the detail.

Among the channels deeply trenching the continental platform Prof. Hull describes those of the Loire (which takes the form of a double canyon, and is traceable to a depth of 9,000 feet); the Gironde and the Adour. This last is the greatest of them.* At six miles from the shore it passes into the Fosse de Cap Breton incising the platform to a depth of 702 feet, where it is covered by 348 feet of water. At 15 miles it receives a tributary channel from the south. It rapidly deepens into a canyon with walls 4,000 to 6,000 feet high, and ultimately opens to the floor of the ocean at 9,000 feet. It bifurcates and encloses a tract of shallower ground. It was considered by Alphonse Milne-Edwards as the ancient bed of the Adour. South of it the

* Explored by the Travailleur Expetition in 1880. *Bull. Geog. Soc.*. Paris, vol. iii, p. 113, 1882.

Spanish shelf is reduced to six to twenty miles in width, but it is indented by several short ravines or deep bays. Other amphitheatres indenting the Biscay shelf are noticed.

The canyons are repeated off Spain and Portugal. The Caneia (opposite to cape Penas) in a distance of twenty miles descends to 8,280 feet and bends in the middle of its course. The Lima dessects the platform to a depth of 5,622 feet, where it is already submerged another 1,200 feet. The channel of the Douro incises the platform to within 14 miles of Oporto. Off Mondego and off cape Carvoeiro are canyons 5,000 feet or more in depth cutting back into the continental platform. The Grand canyon of the Tagus is especially well developed, with its apex five to six miles from cape Razon. At 35 miles from the apex is a branch round an isolated rock or sea stack which rises to within 396 feet of the surface. Here and adjacent portions of the declivity suggest a lower platform corresponding to the submergence of the Blake plateau in a general way (reviewer). The sea stack is only an isolated fragment of the platforms. Of several of the canyons Prof. Hull gives sections sustaining his conclusions, which may be cited in his own language.

"Were there no other suboceanic channels than that of the Adour, it would of itself be sufficient to demonstrate its own fluviatile origin and that of all others here described. For what are the characteristics of a river-valley draining a plateau and adjoining regions? They are first, a continuous deepening of the bed of the channel in the direction of the outlet; second, continuous widening of the channel in the same direction; third, a widening course; fourth, lateral tributaries. All these characterize the suboceanic channel of the Adour. On the other hand they are not characteristic of seismic fissures, or of fissures formed by faults or any other processes with which we are acquainted on the land surface. We are familiar with valleys with similar characteristics, but waterless, entering the great valley of the Nile or the shores of the Red sea, or traversing the region of Arabia Petraea and southern Palestine, where rainfall is either absent or only intermittent; but we do not hesitate to recognize in them the channels of former streams and rivers, though they are now dry. No other theory than that here advanced will, I venture to hold, serve to explain their origin and presence under the waters of the ocean."

In this paper Hull reviews the question of the date of

the late elevation, etc., somewhat more fully than in the former one, and one point may be added; namely, his citation of Prof. Edward Forbes, showing that the flora of the south and west of Ireland gives evidence of former connection with Spain.

Another paper deals with the more scanty evidence off the west coast of Africa and in the Mediterranean. Beyond the strait of Gibralter, the continental platform loses much of its importance, or sometimes disappears and passes into a more gradual slope to 1,200 fathoms. "This slope in all probability consists of a succession of minor terraces breaking off in cliffs." But to determine this requires more soundings. Opposite the strait and between Morocco and the Canary islands, there is a broad terrace of 50-60 miles between 600 and 1,000 fathoms. It may represent a shelf indicating a long pause in the process of elevation or depression of the crust of the earth. It is illustrated in a section. At other points the declivity is steep as off Europe, with the base of the slope at 2,000 fathoms or more. Prof. Hull describes to a further extent the canyon of the Congo, so systematically worked out by Buchanan as to leave no doubt of its river-like form. But this has already been mentioned in America by Mr. Upham and the reviewer. Hull traces it to a depth of 7,200 feet, in a distance of 122 miles. Another submarine valley off the coast of Guinea (here the shelf is 40-50 miles wide), also described by Buchanan, is called the "Bottomless pit," of like character with that of the Congo, surveyed because of the breaking of cables in crossing it. There is not sufficient information to work out canyons for the Niger and Orange rivers, but they should be expected. Here the slope of the great declivity is very steep. About this time, Mr. Henry Benest published his replica of the Congo valley, worked out in fine detail off Cape Verde islands from special cable surveys, where the soundings were taken close together for the purpose of discovering the valley.

Referring to the Mediterranean, Prof. Hull says that while a late relative elevation of the land and sea occurred to the extent of 7,000 or 8,000 feet, it must have influenced the bordering countries and the Mediterranean, but he

would not expect the features to be so well defined in the confined basin as in the Atlantic, especially the declivity descending from the platform. Along the gulf of Valentia the continental platform is unusually broad reaching sixty miles in width, where it breaks off suddenly at about a hundred fathoms. Indenting the shelf and declivity from 240 feet to a depth of 6,000 feet, a valley is traceable opposite the mouth of the Ebro. But the soundings are not sufficient for showing the detail. In front of the mouth of the Rhine, where the shelf varies from 25 to 50 miles, and limited by about the 100-fathom line, the isobaths of the declivity show the course of the valley to a depth of 7,200 feet.

But the most important discoveries of such valleys were made in the gulf of Genoa by Prof. Arturo Issel of the University of Genoa.* The continental platform has a breadth of seven miles and is defined at a depth of 660 feet, where the edge is indented with many sinuosities. These notches of submarine valleys are also shown at depths of 500 and 1,000 metres. This last depth is reached at from 8 to 14 miles from the coast. Prof. Issel has worked out the channels as the submarine continuations of seven rivers to a depth of 900 metres, or about 3,000 feet, and concludes therefrom that a latè elevation to that amount obtained. The land portion of some of these valleys has been excavated out of the Eocene formations, or in some cases out of the Pliocene, Miocene and the Eocene, all three, showing their age to be Pleistocene. But doubtless the maximum depth of the valleys had not been reached. Here is additional confirmation of the age of the late elevation of western Europe, arrived at in a most satisfactory manner. The erosion of those wide, deep valleys, excavated since the Pliocene, involves a lapse of time of long duration much greater than has been granted by many of us for the Pleistocene period.

Cavalière Jervis, of Turin, calls attention to Pliocene clays occurring at an altitude of 1,640 feet at Pianfei (Cuneo). Such commonly skirt the Apennines from one end to the other, and are overlaid to a considerable elevation with Pleistocene clays and sands. But in Sicily the Plio-

* *Comptes Rendus des Sciences.* **Nos. 24th and 31st, Jan. 1887.**

cene strata occur to nearly 3,200 feet. This shows great difference in changes of level compared with that of the Atlantic margin which was one of elevation during the Pliocene times.

Prof. Ethridge, Prof. Rupert Jones, Mr. Benest and others, who had given more or less consideration to the subject treated of by Prof. Hull have expressed conclusions supporting him. Sir Archibald Geikie said that while there might be dissentient opinions, Prof. Hull's methods were the sound ones. He considered that the processes of erosion shown by Hull went back to Tertiary times, otherwise giving a preliminary acceptance of Hull's views. Mr. W. H. Huddleston says: "what evidence is there that any portion of this part of Europe was raised 6,000 feet—during a period so recent as the Pliocene?" as if the valleys themselves were not evidence, and in a paper which he published with a fine bathymetrical map he leaves out just those *little unimportant things*—the channels—which are the fundamental feature of Prof. Hull's work. But Hull further replies, referring to the community of origin of the fauna and flora of Iceland and Scotland (representing a minimum elevation of 3,300 feet), also to the floral connection of Ireland with Spain, the late glacial conditions of the Atlas mountains and their greater extent in Europe, the late connection of Africa with Sicily and Italy, and the migration of animals by this bridge.

As recognized by several of his confrères, Prof. Hull has opened up a new science in Europe. Scattered data had been accumulating, but it was not a science. Most of his critics want longer time allowance, preferring to extend the features over more periods rather than allowing more time to the recent geological epochs, but this difficulty will right itself. The lower parts of the submarine channels may belong to earlier Tertiary times, if so, they were reopened about the beginning of the early Pleistocene period. But some have not learned the grammar of the science, consequently their translation can scarcely be accepted with authority as it does not show the real difficulties. The great difficulty in accepting these submarine valleys as of atmospheric origin lies in the fact that they are world wide

and would imply tremendous changes all over the earth since middle Tertiary times. These changes in the mountains have been more or less studied, but their counterparts beneath the sea are less accessible and have hitherto been largely passed over. Now they have their innings, and Prof. Hull has been a creator of a new chapter of earth's science. Hull it was who specially surveyed the Jordan-Arabah valley, which is the continuation of Prof. J. W. Gregory's "great rift valley." This circumstance specially fitted him for judgment on the submarine valleys, although the evidence was less complete than he would wish for. Yet in the face of Prof. Hull's evidence Prof. Gregory made the following criticism:

"Prof. Hull's theory has the attractiveness of simplicity, but it involves the very improbable assumption of a 9000 feet elevation of the coast, whereas there is no proof of such elevation on the adjoining shores. This improbability renders necessary a careful consideration of the alternative theories of the formation of these submerged canyons. There is no doubt that some of these channels are submerged river channels, but in many cases the explanation is doubtful. Thus Marcel Bertrand has explained the 'Hurd deep' as a line of subsidence by folding, and that suggestion must be refuted before we can accept the Hurd deep as a river channel. Another theory explains these channels as canyons of deposition instead of canyons of erosion. For instance there is the canyon off the mouth of the Congo, which Buchanan attributes to materials brought down by the river being deposited on either side of the mouth. In some cases these canyons occur where it is quite impossible that they could have been formed by subsidence; e. g. at the eastern end of lake Geneva, where the Rhine flows into the lake, there is a canyon which cannot have been formed by erosion. Are Prof. Hull's canyons genuine canyons, or are they to be explained by other theories? In the case of the 'Hurd deep', there is the evidence that it is a probable line of warping. In regard to the Irish channel river there is no single depression such as Prof. Hull's diagrams suggest, but a series of elongated banks formed by the action of currents * * * The paper would have been more convincing had it given a monographic treatment of one or two cases, instead of a general survey of a wide field. The existence of some submerged river channels is probable, but as there are alternative theories explaining the facts, every case has to be judged on its own merits."

To this, Prof Hull replies that "questions of probability or otherwise in natural science subjects are matters which I (Hull) cannot possibly recognize." The alternative theory of the Congo based on the building up of the continental shelf and slope to a hight of 6,000-7,000 feet with the channel of the river, doing this work kept open is simply an impossibility, for the power of the current soon

ceases, as shown by the obstruction at the mouth of the river itself, and the tendency of the marine currents is to fill the hollows. Here the reviewer would add a few words, as he has been anxious to discover the evidence of any other explanation for the phenomena of the submarine valleys than that they were of atmospheric origin; for one one knows better than Prof. Hull himself the startling consequences of such conclusions. As Dr. Gregory's "destructive criticism" embraces the most comprehensive detail, they may be examined. When Dr. Gregory tells us that Prof. Hull's theory, which is an induction from ascertained phenomena, is based on an "improbable assumption"; that a channel carrying down mud may remain open, while a continental shelf of 7,000 feet or more in hight is being constructed, is a valid alternative theory; that the "Hurd deep," with precipitous bluffs, lies in the line of warping, without offering evidence of fact; that the Rhone canyon, in a small mountain lake is a parallel case to canyons in the continental shelf (and even the critic's assumption that such is not a true canyon is very much within the range of non-acceptance) that the Irish sea channel does not exist (Here Prof. Hull has not told the whole story, but the reviewer has verified the deepening channel from St. David's head to the edge of the continental shelf though possibly obstructed in the vicinity of 52-fathoms, it finally incises the slope to a depth of 6,810 feet, where its surface is submerged only 588 feet on one side and 3,000 feet on the other, and beyond to 8,400 feet) we are led to conclude that Dr. Gregory and others have found no satisfactory alternative hypotheses, for lack of which is offered the above "destructive criticism," but this utterly failing greatly strengthens Prof. Hull's position. The clear analyses, though incomplete, of the valleys of the Adour and Congo are of the nature of monographs asked for. Even with these two absolutely complete, they could not have satisfied the hypothesis concerning the continental changes without the great amount of cumulative evidence which the author has assembled and skillfully woven into a chapter, the weakness of which does not lie in such objections just mentioned, but in not considering Dr. Gregory's position that

"the plan of the earth may be attributed to the continual foundering of the earth's external shell," a place for which may be found later, but is not necessary at least at this time.

Whatever the explanations of the great land valleys extending across the continental shelf and down the continental slope, to Prof. Hull is due the honor of assembling these great phenomena together, and showing that in a general way they belong to the same cause, and so far as has been ascertained have been fashioned by atmospheric and river erosion. The reviewer regards the difficulty of such acceptance as not in their form but in the consequences of such phenomena, for they are universal. Their development requires more time than is popularly assigned to the late geological periods. This impression will have to give way to the evidence, if not sustained. Doubtless adjustments will be obtained on this point. We do not know the causes of changes of level, nor do we need to wait till then to accept the facts. Were the phenomena alternating? The continental shelves seem to challenge such assumption; if sychronous then an incomprehendible change of hydrosphere or lithosphere, or both, or a depression of the ocean's bed—even the enormous changes of level of the Asiatic plateaus in recent times we accept without understanding them. The facts of the submarine valleys are now too well established to set aside because we do not know more about them. They form a new chapter carrying us further in the unknown history of the surface features of the earth. We are particularly fortunate in having this work done by the author of the "Geological Survey of Western Palestine,"* who as already mentioned, has studied the remarkable Jordan-Arabah valley.

Returning now to Prof. Hull's contributions we find "The Physical History of the Norwegian Fjords."† The fjords are described. But we shall pass on. As to their origin "the fjords are primarily the outcome of rain and river erosion, continued through long ages of geological

* With Special Reference to the Mode of Formation of the Jordan-Arabah Depression and the Dead Sea." Pub. by the Palestine Explor. Fund, London, 1889.

† Loc. cit.

history · modified somewhat by glacial action in later times, and to a less degree by changes in the relations of land and sea; in a word they are simply partially submerged river-valleys." "According to the Scandinavian geologists, the cause of the rapid shallowing of the great sea-lochs, on approaching their outlet in the North sea, is the piling up of enormous masses of morainic matter by former glaciers which descended these valleys." Hull considers that the channels do exist beneath the various sediments while the sea floor has been generally leveled over by tidal and other currents. While the Sognefjord reaches to a depth of nearly 4,000 feet, from the character of the continental slope Prof. Hull concludes that the late elevation was at least 6,000-7,000 feet. He cites Prof. Brögger as authority for the conclusion that the late elevation reached at least 8,528 feet during the epoch of the greatest ice sheet; this conclusion being derived from the occurrence of a bed of littoral shells at a depth of 2,600 metres.† Prof. Hull calls attention to the marine terraces of Trondhjem and Christiania fjord to the hight of about 615 feet, while between these points nearer the coast the terraces are much lower. These show later changes of level.

Prof. Hull's first paper was suggested by the evidence of great changes of level shown by Warren Upham and the reviewer before he had made his own classic researches. The subject was "Another Possible Cause of the Glacial Epoch,"* which he attributed primarily to the great changes of level, afterwards shown in his own contributions, the land having attained to the great elevation of at least 7,000 or 8,000 feet in the early Glacial period, although there was subsequently an interglacial or post-glacial submergence of 1,200 feet in Britain. These contributions are new facts treated in a philosophical manner, and could now perhaps be put in a monographic form. They must be a foundation for all subsequent research in terrestrial movements and the consequences thereof. They also prove that a man's greatest work is not confined to his earlier years; and in spite of all he has done, the author considers this

‡ Norges geologiske undersegelse, No. 31, p. 683.

his best work, which has been fully recognized in a recent great monograph by Dr. Nansen.

NOTE.—Reference was made on page .. to Prof. Broegger's citation of the occurrence of shallow water found at great depths. The dredgings were made at several localities near Spitzbergen and between Iceland and Jan Mayon. In the former region a considerable number of Arctic shells were obtained at 656 and at 1333 fathoms; and in the latter at 495, 729, 957, 1009, and 1309 fathoms. Dr. F. Nansen's conclusions that they have been transported by ice in recent time is extremely improbable, and this being the case Prof. Brögger says, "no other explanation is left than the supposition of the former uplift of the sea bottom" to about 8400 feet. (loc. cited).

ON THE ORIGIN OF THE CAVES OF THE ISLAND OF PUT-IN-BAY, LAKE ERIE.*

By EDWARD H KRAUS. Ann Arbor, Mich.

The island of Put-In-Bay, Ohio, in the southwestern portion of lake Erie, has for some time past been noted for its interesting caves. There are four, which are now open to the public. They are Danssa's, Kindt's, Perry's, and the "Crystal" or "strontian" caves. The first two are interesting because of their stalactites.† The "Crystal" cave is instructive on account of its beautiful crystallizations of celestite.‡ Perry's cave is the largest of the four and is perhaps over 200 feet in its extreme dimensions. The maximum hight of this cave is about ten feet.

The rocks of the island have been assigned to the Lower Helderberg epoch. These horizontally stratified rocks have been greatly disturbed in the immediate vicinity of the caves, but, as yet, no trace, whatever, of volcanic action has been noted at any point in this region. The peculiar condition, however, of the roof and also the floor of the Perry cave gives us a clew to the probable cause of the rock disturbances, if not of all the caves, of Perry's at least.

* Read before the Philadelphia meeting of the Geological Society of America, December 29, 1904.

† The stalactites of this cave have recently been studied by Fuller in regard to their bearing upon recent land tilting. *Science, N. S. xx, 161, 1904.*

‡ *Wright*, a recently discovered cave of celestite crystals at Put-In-Bay, Ohio. *American Geologist. xxii, 261.*
Kraus, Occurrence and Distribution of Celestite-bearing Rocks, *American Journal of Science, xix, 1905.*

The roof of the Perry cave is very interesting in that it is gently arched. Many of the strata, composing it, do not, however, extend entirely across the cave. The roof, therefore, in some places has an appearance similar to inverted steps. The floor conforms to the uneveness of the roof, for where there is a depression in the former there is a corresponding projection downward in the latter and vice versa. This phenomenon is, doubtless, the result of folding and subsequent collapse.

The question, which must be settled first, is what has brought about the rock disturbances inasmuch as there is no evidence of volcanic action. During the past summer several wells were drilled on the island. The one on the farm of Louis Schiele on the southeastern shore of the island reached a depth of 170 feet. Below a depth of 100 feet alternate layers of gypsum, shale, and limestone were encountered. Some of these deposits of gypsum were 10 feet thick. The cores* between the depths indicated show that a very large amount of brecciation has taken place, giving evidence to the fact that the gypsum is the result of the *hydration* of anhydrite.

The hydration of anhydrite is always accompanied by an increase in volume. Credner,† Fritsch,‡ Bauer,§ and Geikie ‖ estimate the increase in volume, thus brought about, to be approximately 33 per cent. On the other hand, however, such reliable authorities as J. D. Dana** and Naumann-Zirkel †† place this increase in volume at a much higher figure, namely 60 per cent. J. Roth,‡‡ moreover, has carefully calculated the change in volume, which must result when anhydrite takes up two molecules of water of crystallization to form gypsum, and estimates the same to be as high as 62.3 per cent. Perhaps, in some instances, values between those just indicated would represent the true amount of increase.

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* The well was sunk by means of a socalled "shot drill" about three inches in diameter.

† *Geologie*, 8te Auflage, 1897, 221.

‡ *Das Gotthardgebeit*, Bern, 1873. Anhydrit und Gyps, 119.

§ *Lehrbuch der Mineralogie*, 2te Auflage, 1904, 847.

‖ *Textbook of Geology*, 4th Edition, 1903 I., 453.

** *Manual of Geology*, 4th Edition, 1895, 138.

†† *Elemente des Mineralogie*, 13te Auflage, 1898, 546.

‡‡ *Chemische Geologie*, 1879, I, 89.

For our consideration it is important that there is actually an increase in volume when anhydrite becomes hydrated and concerning this point there can be no question, whatever, as the cores from the Schiele well furnish the best of evidence. Furthermore, all the authorities, cited above, agree that this increase is sufficient to exert enormous pressure directed upward, and also, that the disturbances, which are generally encountered in the rocks overlying gypsum deposits, are to be referred to such a cause. Bischoff* and Credner† cite many instances where disturbances have been noted. Among the various localities, which are mentioned by the former, we find especial reference to two American sections, namely Oneida and Onondaga counties in the state of New York, where very peculiar conditions of the strata exist. In these localities very considerable deposits of gypsum occur—in some instances as thick as 60 or more feet.

There is no question as to the enormity of the force exerted by freezing water and yet, the increase in volume, caused by the water passing from a liquid to a solid condition, is but 9 or 10 per cent. It has, nevertheless, been estimated that the force thus exerted is no less than 138 tons per square foot‡ or 1,916 pounds per square inch. Thus, we find, if we consider the lowest figures, given above, as correct for the increase in volume accompanying the change from anhydrite to gypsum, namely 33 per cent, that this increase is more than three times that indicated above for freezing water, and hence, a much greater force would necessarily be exerted, even if the compressibility of gypsum be somewhat greater than that of water. In this connection both Bischoff and Credner say that this increase in volume is the cause of the uplifts, folding, and faulting, which are so commonly noticed in the overlying and adjoining strata—a phenomenon which formerly gave rise to the notion that gypsum was of eruptive origin. Dana, Geikie, Prestwick, and many others also indicate the fact that the hydration of anhydrite is usually accompanied by local disturbances.

* *Chemische Geologie* II, 188-197.

† *Geologie* 8te Auflage, 1897, 200-201.

‡ *Brigham*, A text-book of Geology, 1902, 24.

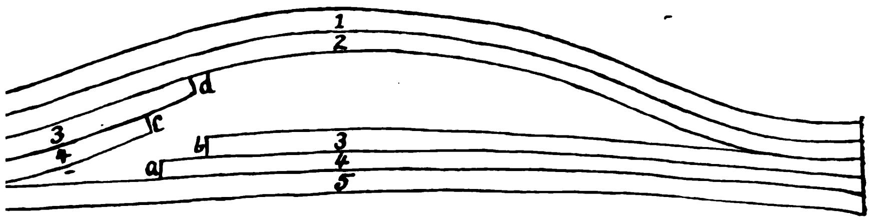
Thus, knowing that in the immediate vicinity of these caves there is a large deposit of gypsum, formed by the hydration of anhydrite, we must assign to this change the cause of the rock disturbances of the locality. Gypsum, however, is quite readily soluble in water, for according to Kohlrausch and Rose* one part of gypsum is soluble in 483 parts of water at 15° C. That a very abundant supply of water is present to bring about the solution of the gypsum is evidenced by the fact that the level of the lake is reached at a depth of about 40 feet. This can be readily seen in several of the caves.

The passing of gypsum into solution on a large scale is well known and may be observed in almost all gypsum quarries. When the mass of the mineral, thus removed, is of a considerable size, the overlying strata in many instances sink. Among others, Bischoff and Credner cite many such cases. Bischoff says, that oftentimes the rocks overlying gypsum deposits first undergo uplift, folding and so forth and then as the mineral below is dissolved and removed these strata may settle, assuming a position nearly horizontal, thereby not revealing the fact that they had been disturbed at all. Credner* also refers to interesting phenomena at Eislehn, where conditions somewhat similar to those at Put-In-Bay exist.

In the case at the Perry cave, we have had the folding. Solution has also taken place but not all of the overlying strata settled into a nearly horizontal position—some were left in the position they assumed as the result of the folding and now appear like an arch on a bridge or vault.

The accompanying figure shows an ideal section through the Perry cave. Layers 1 and 2 show that the roof of the cave is still arched. Layers 3 and 4 represent the strata, which give evidence of a collapse for they do not extend continuously across the cave. The step-like arrangement of the strata at a and b conforms exactly to c and d in the roof. These, however, are not the only evidences of a collapse, for we often can note concave or convex unevenesses in the floor and directly above we find

* *Geologie* 8te Auflage, 1897, 221, 222.



forms in the roof, which correspond to the uneven places in the floor.

We may, therefore, sum up as follows: The change of anhydrite to gypsum has given rise to the folding which is quite prevalent in this section, the abundant water supply has caused the solution of large amounts of gypsum, whereby a partial collapse of the overlying strata resulted, leaving an open space between the strata, which still remain folded and those which settled. No doubt this explanation will also apply to the formation of some of the other caves. In the "Crystal" cave it is difficult to make observations as to the relation of the roof to the floor on account of the large number of well developed celestite crystals, which occur attached on all sides of the cave. In Kindt's cave the conditions are somewhat similar to those in Perry's. As yet I have not been able to examine Danssa's cave, but inasmuch as this cave is in very close proximity to the Perry cave, the above explanation, no doubt, also applies to it.

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THE GEOLOGICAL AND TOPOGRAPHICAL FEATURES OF THE CITY OF MONTEREY, NUEVO LEON, MEXICO, AND ITS VICINITY.

Ernest Wittmann, Monterey, Mex.

Sir:—While recently in the City of Monterey, Mexico, I was greatly struck by the singular geological formation of the canyons and mountain ranges in the vicinity. The lofty and slender peaks of blue limestone rising abruptly from the level campania, with almost vertical stratifications which give them the appearance of fluted columns are truly impressive, not to say weird-looking, differing so greatly from anything to be seen out of New Spain. One fully recognizes the force of Humboldt's words:

"There is scarcely another part of our globe where the moun-

"tains present so extraordinary a structure as in New Spain. "* * * * Those immense plains elevated to the hight of our "highest mountains; those gigantic peaks hewn with such regularity "into conical forms; those abrupt chasms, so deep that the eye can "scarcely penetrate their gloomy abyses;—nothing in our regular "formations has prepared us to see and comprehend these things, "nothing fills the space which exists in our minds between our pre- "vious observations and that which suddenly strikes our view."

Very remarkable, too, are the horizontal beds of chalk-like deposits called "Sillares" overlying the water-bearing stratum of gravel, the more so as they, in common with the hard limestone appear to be absolutely non-fosiliferous.

Finding that my friend, Mr. Ernest Wittmann, a scientific Austrian gentleman residing at Monterey had spent considerable time in studying these interesting features, I suggested that he write out some of the results of his investigations, particularly as so little seems to be known of the geology of this part of Mexico. He has complied with my suggestion, and hopes, with me, that the inclosed manuscript may prove of sufficient merit to justify its publication in your columns.

220 West 57th St., E. SHERMAN GOULD.
New York.

The city of Monterey in the state of Nuevo Leon, well known as one of the best developed centers of industry of the republic of Mexico, is also a very interesting point for geological study.

On the southerly side of the city, rises the great range of the eastern Sierra Madre with its picturesque foot hills; east of it, and divided from it by the deep and narrow Huajuco canyon, the Sierra de la Silla, or Saddle mountain, rears its lofty peak.

West of the city are the foot hills of a mountain range called the Sierra de la Mitra, a branch of the Sierra Madre. Upon these foot hills stand the ruins of the old "Bishop's Palace," partly destroyed by the cannon balls of general Taylor.

Between the Sierra Madre and the Sierra de la Mitra, lies the valley of Santa Catavina through which runs the river of the same name. On the north side of the city stretches a level plain, some portions of which are very fertile and yield rich harvests of corn, sugar cane and vegetables.

About five miles north of the city this plain is broken

by an isolated mountain, some four miles long and two and a half wide called the Sierra del Topo, renowned for its hot sulphur springs which appear on the southeasterly slope near the little village of San Bernabe.

Farther north are other mountain ranges which close the valley on three sides, having their slope from west to east, with the Sierra del Topo as a center.

On the east side are low hills, between which the rivers Santa Catarina and Pescaria find their way.

Such is the topography of Monterey as it appears today. But what enormous changes must have taken place in former periods!

The Sierra del Topo and the Topo Chico which rise out of the plain that bounds the city on the north, are of plutonic origin, overlain by vast diluvial formations, to which class all the other ranges also belong.

The Topo Chico is of a nearly pure limestone (99.20%), very glossy, but semi-cristalline, with veins of pure gypsum and numerous "blow-outs" (galena) near the summit, with lead deposits at its northwesterly foot, and sulphur springs of a temperature of 102° Fahr. on the east. The strata of the surrounding mountains indicate an upheaval towards the Topo Chico. They consist also of limestone of varying density, intermingled with magnesite, etc.

Imbedded in these mountains are large deposits of iron and lead ore, mostly in pockets, as well as deposits of rock salt and other alcaline rocks with sulphate of soda in excess. In many places the soluble portions of these rocks are washed out, leaving channels for the subterranean watercourses, some of which are sweet and others more or less mineralized.

At a former period, probably after the upheaval of the Topo Chico mountain, the valley of Monterey was a vast lake. The foremost scientist of his day, Alexander von Humboldt recognized this fact. Natural appearances indicate that the present level of Monterey was probably more than 160 feet below the surface of this lake which must have been inclosed by hills on the east side of the valley, through which at a later period it found an outlet. The evaporation from this lake must have been enormous, and

the water charged with lime from flowing through a limestone formation, would naturally leave a chalky deposit. More than 130 feet above the present level of the town we find this deposit lying in thick beds, and also underlying the city at a depth below the surface of from one to ten feet, with a thickness of from 30 to 40 feet.

Till within the last ten years this deposit of soft limestone, called "sillar," which has the color and consistency of chalk and lies in horizontal beds, has been the only building material in use in the city of Monterey, and it is still employed for nearly all common buildings on account of its cheapness and many excellent qualities. It loses its coherence when subjected to a temperature below the freezing point.

Underneath this formation is found a bed of coarse gravel mixed with large boulders through which an abundance of fresh water flows. The depth of this gravel bed has never been ascertained. The present water supply of the city comes from wells sunk down to this formation. In these wells the water shows a tendency to flow from southwest to northeast. In some the flow is clearly visible.

As we do not know how much of the sillar deposit has been carried away in solution, or how the temperature and climatic conditions may have changed since the time of its formation, it is impossible to make an exact estimate of the time required to lay down the vast beds which now exist. Granting that the conditions were the same, or nearly the same as they are to-day, we may assume the evaporation from the surface of the former lake to have been about three sixteenths of an inch in 24 hours, or about 6 cubic feet per square foot of surface, per year. The evaporated water may have contained 0.385 parts of primary calcium carbonate in 1000 parts of water, or 0.24 of secondary carbonate of lime at a temperature of 59° Fahr. An analysis recently made by Mr. Butsch, chemist of the Monterey steel works, resulted in 0.23 parts carbonate of lime in 1000 parts of water.

The former temperature may have been higher than 59°, so we may assume 0.25 parts in 1000 parts. This would give a yearly precipitation of 0.0015 ft. or 15 feet in 10,000

years. As the precipitation would be the same whether the water was 5 feet or 150 feet deep we cannot estimate the true thickness of the bed from the difference between the highest and the lowest level, but we may safely assume that the deposit below Monterey represents the least possible thickness.

Reasoning as above, a period of not less than 22,472 years would be necessary to deposit the existing bed of sillar. But how many thousand years have passed since that lake disappeared and the rivers took its place and commenced their own work of destruction and reconstruction? Our surest guide in geological study is lacking in this case. No fossils are found in the sillar, no shells of Crustacea which would help to fix the period of the deposit. At least the author has never succeeded in finding any. But the undisturbed condition of the horizontal beds of sillar indicate that since their deposition commenced there has been no further volcanic eruptions in the valley.

Below the gravel beds of undetermined thickness, we would surely find the disrupted and uplifted lime rock, and below that again the limestone of Topo Chico. An artesian well sunk to a considerable depth in former years failed to give definite results, for the drill broke and the work was stopped when a depth of 2,000 feet was said to have been reached.

A possible explanation of the origin of the Topo Chico mountain may be that a mass of plutonic rock in a state of refusion and under enormous pressure partly penetrated and partly uplifted the overlying stratum of diluvial rock. The rounded top of the mountain leads to the belief that the whole mass while in eruption was in a semi-fluid condition. The eruption was followed by an outburst of sulphurous gases which must have continued for a long time to penetrate the cracks and fissures caused by the contraction of the crust while in process of cooling. These fissures, from half an inch to over three feet in width, have been nearly all closed by the action of the fumes of sulphur which changed the carbonate of lime to sulphate of lime.

Not all of these cracks and fissures have been thus nearly all closed by the action of the fumes of sulphur

about three-quarters of a cubic foot per second comes to the surface at a temperature of 102° Fahr., and charged with sulphur to the saturation point at this temperature. Other ingredients are also found in this water, but in insignificant quantities. The temperature of the water indicates that it must come from a depth of 3,000 feet, and this also conveys an idea of the depth of the plutonic formation which, of course, lies still deeper.

The opinion has been very often expressed that this water is forced to the surface by artesian pressure, but this idea is untenable under the circumstances. It is much more likely that it is the pressure exercised by the expansion of the heated water itself that brings it to the surface.

Sprinkled over the summit of this mountain are small deposits of galena but not on a scale to warrant exploitation. Mining operations are carried on at the northerly foot of the mountain, though with but slender results. There may be a great body of ore somewhere in the vicinity but if so, it has not yet been discovered.

Monterey, October, 1904.

CLASSIFICATION OF THE UPPER CRETACEOUS FORMATIONS OF NEW JERSEY.*

STUART WELLER, Chicago, Ill.

Three classifications of the Upper Cretaceous formations of New Jersey have been published in the reports of the geological survey of New Jersey; 1, Cook's 1868; 2, Clark's 1892-97; 3, Knapp and Kümmel's 1898-1904. Cook based his classification upon the lithologic characters of the beds, fully differentiating the beds of the "marl" series. Clark's classification was based in part upon paleontologic data, but his differentiation of the beds was no advance over that of Cook; he distinguished four major divisions, viz., Matawan, Monmouth, Rancocas and Manasquan. Knapp and Kümmel have differentiated the old "clay marl" series of Cook into five formations, viz., Merchantville, Woodbury, Columbus, Marshalltown and Wenonah, based upon lithologic characters alone.

* Abstract of a paper read at the Philadelphia meeting, G. S. A., Dec., 1904.

The paleontologic studies of the writer not only add very largely to the previous data regarding the faunas of these beds, but also show; 1, that the five "clay marl" formations of Knapp and Kümmel are as sharply differentiated by their fossil contents as by their lithologic characters; and 2, that the "yellow sand" of Cook, which was finally referred to the Miocene by Clark, is of Cretaceous age, being an arenaceous facies of the Vincentown lime-sand formation.

DRUMLIN AREAS IN NORTHERN MICHIGAN.*

ISRAEL C RUSSELL, Ann Arbor, Mich.

There are at least two regions in the Northern Peninsula of Michigan, in which drumlins form the most conspicuous features of the topography. One of these areas includes Les Cheneaux Islands and a part of the adjacent mainland, on the north shore of lake Huron; and the other area is situated principally in Menominee county, to the west of Green bay.

Les Cheneaux islands area embraces about 70 square miles, the numerous drumlins within it are of the elongate, ridge-like type, are in general about 40 feet high, and trend N. W. and S. E. The direction of ice movement to which the drumlins are due, as recorded by striæ, etc., on rock surfaces, was from the N. W. towards the S. E. Many of the drumlins are partially submerged in the water of lake Huron and form Les Cheneaux islands and the capes on the border of the adjacent mainland; the conspicuous parallelism of the longer axes of the islands and of the neighboring capes, is due to this cause. The drumlins are for the most part below the horizon of the Nipissing beach, and have been washed by lake waters so as to remove the greater part of the fine material formerly present on their surfaces, and concentrate the stones and boulders.

The Menominee area occupies at least 150 square miles, and contains many hundred and probably several thousand drumlins. The drumlins are most of the ridge like type, are usually about 40 feet high, and their longer axes trend N. E. and S. W. The till of which they are composed is reddish,

* Abstract of a paper read at the Philadelphia meeting, G. S. A., Dec., 1904.

sandy, without lamination, and contains many flat slabs of limestone which are without orderly arrangement. Boulders of native copper and of specular iron ore found in the till, indicate that it was deposited by a glacier moving from the N. W. toward the S. E. Striæ etc. on rock surfaces in the midst of the drumlins, record an ice movement from the N. E. toward the S. W. The longer axes of the drumlins are not strictly parallel, but vary in trend from N. 32 degrees E. to N. 55 degrees E. The rock on which the drumlins rest, is Trenton limestone, and has a conspicuously even surface; no knobs or crags are present, such as might serve as nuclei for till accumulation. The larger drumlins rise to a uniform hight and if the valleys and channels between them were filled a nearly horizontal plain would be produced. The depressions separating the drumlins are in many instances, smooth surfaced, concave troughs; and in one example there is a well defined trench of this character, about 12 feet deep and from 20 to 30 feet wide, about the N. E. end of a small drumlin and extending along its sides. The surfaces of the drumlins to a depth of some 12 to 18 inches, are composed of exceedingly fine, dust-like loamy sand, which contains loose stones and boulders.

The drumlins are for the most part smooth-surfaced, half cigar-shaped hills of the normal type, but in a few instances instructive irregularities are present. Among these are: a flattening of a portion of the normally elliptical ground plan as if a marginal portion of a well-shaped drumlin had been removed by erosion, leaving an abnormally steep slope; deep transverse trenches at right angles to their longer axes; straight or curved trenches extending from their summits down their sides; irregular pits in their normally smooth surfaces; and in one instance, a terrace-like shelf with a convex longitudinal profile, parallel with the crest line of the drumlin on the side of which it occurs.

In the valleys between the drumlins, there are several eskers, which as a rule are in a general way parallel with their longer axes, but in a few instances cross their trend nearly at right angles. In one example, an esker extends each way from a transverse trench in a drumlin; and in a few instances, eskers occur on the tops of drumlins.

From the evidence just summarized, the conclusion is drawn that the drumlins of the Menominee area were produced by ice erosion from a previously deposited till sheet. This explanation is essentially in harmony with the theory of the origin of drumlins advanced several years since by professor Shaler.

Attention will also be invited to the importance of ice erosion in shaping the topography of glacial deposits in other regions.

FAUNA OF THE CLIFFWOOD CLAYS.*

STUART WELLER, Chicago, Ill.

The flora of the Cliffwood clays on the south shore of Raritan bay, New Jersey, has been studied in detail by Hollick and Berry, but no careful study of the fauna of these beds has previously been attempted. An investigation of this fauna by the author shows its close relationship to the faunas of the "clay marl" formations above, but at the same time shows that the Cliffwood fauna possesses an individual charcater of its own. The geographic distribution of the beds containing the fauna is limited to a small area between Cliffwood point and the head of Cheesquake creek, while the superjacent Merchantville clay, with its uniform fauna, extends entirely across the state of New Jersey. The basal line of the Merchantville clays can be traced as a natural geologic horizon across New Jersey, separating the heterogenous, usually non-marine Raritan beds beneath, from the remarkably constant marine beds of the "clay marl" formations above. The marine Cliffwood clays represent a limited transgression of the marine conditions from the Atlantic basin, into the area where non marine sedimentation had been in progress during the greater portion of Raritan time. These Cliffwood clays are the most notable example of such marine sediments in the Raritan, but not the only example, since marine fossils have also been found towards the base of the Raritan near Sayresville. In mapping the Cliffwood clays they should be included in the Raritan rather than with the superjacent beds.

* Abstract of a paper read at the Philadelphia meeting, G. S. A., Dec., 1904.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The New Madrid Earthquake, by EDWARD M. SHEPARD, Springfield, Missouri, (Journal of Geology, Vol. 13, pp. 45-62.)

This paper is of unusual interest because of the explanation of the earthquake which is there proposed. There have been many theories advanced as to its cause during the century which has nearly elapsed since the quake, but practically all must be considered as mere suggestions, as the writers have in general never visited the field nor familiarized themselves with the details of evidence. The fact that the problem was approached through hydrologic investigations is of interest.

Professor Shepard's explanation may be summarized as follows: The deposits in the New Madrid region consist of superficial clayey beds underlain by fine sands saturated with water under considerable artesian pressure. This clay, it is thought, had been slowly undermined during centuries by the steady removal of fine sand by springs, which still exist in considerable numbers and bring up fine sand to the present day. A slight earthquake originating probably in a readjustment of some fault in the Ozarks communicated itself to the unconsolidated deposits, fracturing the clay capping, upon which the artesian pressure was relieved by the extrusion of the sand and water as described by nearly all observers, thus permitting the warping of the surface through the re-arrangement of the materials underlying the surface clays. A similar explanation is thought to be applicable to the changes near Shreveport, Louisiana.

Professor Shepard's suggestion as to the origin of the shock in the Ozark region seems to be a good one. The wave-like undulations of the surface during the quake are characteristic of shocks which have been transmitted to unconsolidated materials from the harder rocks, and its assumed western origin is borne out to some extent by the fact that the shock became progressively less severe through the settled regions to the East. The West was not then settled. [1811-12.]

The reviewer, who had the opportunity of accompanying professor Shepard on one of his trips into the region, agrees with him as to the probable point of origin of the earthquake, and as to the existence of a clayey surface underlain by quicksand saturated with water under artesian pressure. He believes, however, that the springs, occurring as they do only in stream beds sunk some distance below the level of the surrounding flats, represent simply the normal inflow of groundwater, and are not of deep seated origin. Nor does the sand brought up by such springs seem to be in sufficient quantities to account for any extensive undermining. On

the contrary, so far as can be observed, the extrusion of sand in considerable amounts seems to be a feature strictly associated with the earthquake. In the writer's opinion there was little preliminary undermining, the extrusion of the quisksand, which when saturated will often flow like water, being limited essentially to the period of shock. The permanent warping of the surface would appear to be due to the contemporaneous undermining at certain points due to the removal of the sand and a readjustment within the quicksand bed at other points. M. L. F.

New Species and a New Genus of Batrachian Footprints of the Carboniferous System in Eastern Canada. By G. F. MATTHEW. [Trans. Royal Society of Canada, 2d Ser. vol. x, Sec. IV, p. 77, Ottawa, 1904.]

This article is the result of Dr. Matthew's studies of some additional species of fossil footprints from the Carboniferous system of eastern Canada.

It furnishes a more complete review of the forms already treated of in his former paper published in the Canadian Record of Science, Montreal, and of earlier articles on the same subject to be found in the Bulletin of the Natural History Society (St. John, N. B.) and in the Transaction of the Royal Society of Canada.

The six plates of figures with the article, show how different in type are footprints of the Carboniferous time from those of the Jura-Trias; which is quite in keeping with the distinctness in organization of the quadrupeds of the two epochs.

The article has a special value in presenting more clearly, and from additional evidence, the characters of Dawson's genus Hylopus, which is herein considerably limited. It gives additional particulars of Dawson's remarkable species *Sauropus unguifer*, which is referred to the genus Pseudobradypus (See Can. Rec. Sci., vol. ix, No. 2, p. 109).

Special comparisons of these Carboniferous fossil footprints, are made with those of the living frog and alligator, as regards the number. of toe prints made and the attitude of the toes. The matter of the trail of the belly or the tail shown in some of these fossil tracks is also discussed.

The conclusion arrived at is that there are marked peculiarities in the fossil prints that distinguish them from those of modern reptiles and amphibians, as typified in the alligator and frog, and show them to have belonged to a different order or orders of animals.

As regards the length of stride in these creatures, " the blunt-toed species hold a middle place, and those whose bodies or tails trailed upon the ground, took much shorter steps than the others. Many of the long-toed forms, though not all, had a long stride."

Dodge's Advanced Geography. R. E. DODGE pp. xix and 333. Rand, McNally & Co., 1904, price, $1.20.

This book is uniform with Dodge's Elementary Geography which was noticed in the *Geologist* (vol. xxxiv, p. 197), and compares well with its predecessor in all of its points of excellence. N. H. W.

Students' Laboratory Manual of Physical Geography, ALBERT PERRY BRIGHAM, pp. 153. D. Appleton & Company, New York, 1905. One of the Twentieth Century Text-books edited by A. F. Nightingale, Superintendent of Schools of Cook County, Ill.

The progress of the geological surveys of the states, and particularly that of the United States Geological Survey, has made such books as this possible to the American student. As these surveys have led to a more detailed, as well as a more systematic, examination of the features of the land, they have resulted in a mass of geological and geographical information which, as yet, is very largely confined to the original official reports. It is the task of Dr. Brigham to reduce this information to more simple terms and to bring its final results into sharp and comprehensive expression and individual use, and at the same time to make the student an interested, if not an eager, inquirer in pursuit of geographical knowledge. No young person can go through the exercises required by this categorical inquisition without becoming not only a good geographer but a fairly good geological observer. N. H. W.

The Face of the Earth (*Das Antlitz der Erde*). By EDWARD SUESS, professor of geology in the University of Vienna. Translated by HERTHA B. C. SOLLAS under the direction of W. J. SOLLAS, professor of geology in the University of Oxford. Vol. I, with 4 maps, 2 full-page plates and 48 other illustrations. Oxford, The Clarendon Press. Henry Frowde, London, Edinburgh, Glasgow, New York and Toronto. Price, $8.25. Prof. Suess has written a special preface for the English translation.

We had occasion to notice the French translation of this great work (vol. I) in vol. 27, p. 56, of the GEOLOGIST. The work of course is the same, in an English garb—so closely the same that it has adopted the great fault of the original, i. e., the lack of an index.

At the opening of chapter V (p. 173) is the following statement: "Precise investigation shows that a measurable displacement of any fragment of the rocky crust of the earth, with regard to another, whether it takes the form of elevation, subsidence or horizontal displacement, has not yet been convincingly established." This seems to call in question the evidence on which many important geological principles have been based, such as block mountains and all faulting. We are reassured, however, by the following sentence with which the same paragraph closes: "But if movements do not actually take place before our eyes, yet numerous dislocations show that they have often occurred on the grandest scale, and frequent earthquakes prove that they are not yet at an end."

The work when completed will be one of the most comprehensive and philosophic compends of the features of the earth's surface ever conceived. It exceeds Lyell's as Lyell's surpasses Hutton's, because of the increased knowledge of the globe.

N. H. W.

Elements of Mineralogy. Crystallography and Blowpipe Analysis from a practical standpoint, including a description of all common or useful minerals, the tests necessary for their identification, the recognition and measurement of their crystals, and a concise statement of their uses in the arts. By ALFRED J. MOSES and CHARLES LATHROP PARSONS, 3rd enlarged edition, pp. 444. Price, $2.50, net. D. Van Nostrand Company, New York, 1904.

This work has been entirely re-arranged and much of it re-written. Many of the original diagrams and figures have been discarded, or have been replaced by half-tone photographs of real crystals. "The introductory portion of Part III, Descriptive Mineralogy, has been carefully revised and re-written, a chapter added upon "Occurrence and Origin of Minerals"; the discussion of chemical composition and chemical relations of minerals made more thorough; the optical portion simplified, and the phenomena of radioactivity, fluorescence and phosphorescence described. To those who know the excellence of the earlier edition of this work these improvements will afford reason for greater use and higher appreciation.

N. H. W.

Geology of the Shafter Silver Mining District, Presidio County, Texas. By J. A. UDDEN Texas Mineral Survey, Bull. 8, 60 pp., 1904.

The Shafter mining district supports the only successful silver mines of Texas. This region was studied by professor Udden and a report issued fully discussing the geologic conditions. Shafter is located 196 miles southeast of El Paso, in the Chinati mountains.

The sedimentary rocks are represented by Carboniferous and Cretaceous deposits; the former by the Cieneguita beds composed of 1,000 feet of conglomerates, shales and "mortar rocks"; which are succeeded by the Alta beds composed of 2,000 feet of dark shales and 1,500 feet of yellow sand, both carrying typical Coal Measures fauna; and the Cibolo beds which consist of 100 feet of marly shales and limestone masses, 133 feet of coarsely brecciated limestone, limestone (lower zone of sponge spicules) 85 feet, thin bedded zone (limestone) 470 feet, and capped with 650 feet of yellow limestone. These three formations represent a cycle of deposition or series. No definite relation had been established between this section and the Guadaloupe region of the Permian. He states that some of the fossils from the yellow limestone seem to point to its identity with the Guadaloupian rocks and there is some similarity in the stratigraphic succession; however, the fauna as a whole

can not be considered as indicating such a relationship. The fauna is referable in age to the Missourian of the Mississippi valley. The entire section of Carboniferous rocks is designated as the Chinati series.

The Lower Cretaceous sediments rest on the Carboniferous rocks. Here professor Udden's study of the minute structure of the rocks has enabled him to divide them into formations based on conditions of sedimentation. His section of the Cretaceous rocks, in descending order follows: Buda limestone ? 70 feet; Del Rio clay ? 80 feet; Edwards limestone, 350 feet; Shafter beds. 700 feet; Presidio beds, 400 feet.

The sedimentary deposits are interrupted and tilted by intrusive granites, lava flows, dikes and faults. One of the features interesting to geologists is that the old caves developed in the thick Carboniferous limestone, near the disturbed region, are filled to some extent with ore, which has been one of the productive sources of silver. The faults, fissures and smaller cavities are mineralized also.

The report is illustrated by plates, sections and map. The discussion of the minute characters of the rocks, the topography and structure occupy a considerable space, and numerous sections and lists of fossils are given. J. W. B.

The Tower of Pelee; new studies of the great volcano of Martinique. ANGELO HEILPRIN. Quarto, pp. 62, 23 plates, 1904. J. B. Lippincott Company, Philadelphia and London.

Prof. Heilprin has been an earnest and enterprising explorer of the unfortunate island of Martinique. He has visited it three times. His last visit culminated in a special examination of that remarkable tower which has become one of the famous features of a famous volcano, "Nature's monument to 30,000 dead who lay in the silent city below, it rose up a huge monolith, 830 feet above the newly constructed summit of the volcano, and 5,020 feet above the Caribbean surface,—a unique and incomparable type in our planet's wonderland."

Prof. Heilprin shows that the earliest known, or probable, observation on the embryo tower was on May 31, 1902, about three weeks after the first great eruption. It had an interrupted existence. With a continual tendency to rise it was destroyed by the later explosions and shocks, the summit being specially liable to decapitation. It rose from 20 to 30. feet per day for a period of a month, constantly changing its form, its greatest hight being stated to have been about 5,200 feet, viz: on May 30-31, 1903. On that day it lost 180 feet. The composition of the tower seems to have been pumiceous andesyte; it was constantly penetrated by steam which rose through vertical fissures sometimes even to the summit. It was apparently at first a mass of more or less consolidated andesyte and perhaps of volcanic ejecta of earlier ages, probably

similar in that respect to the cone upon which it rested, or through which it was protruded.

The destruction of the tower began in July, 1903. It was accompanied, and probably caused, by a more pronounced activity of the volcano, producing the dense black clouds which descended the mountain slopes to the sea and are thought to be of the nature of the fatal blast that visited and destroyed Saint-Pierre. After the tower was destroyed, which required but few weeks, a huge dome began to rise in its place. This was made up more or less of lava and was accompanied by frequent discharges of dust and boulders. It rose at about the same rate as the tower. It was sometimes incandescent. By October the dome had reached a hight of 500 feet. Through it protruded small towers, more solid, believed by Heilprin to be the basal parts of the great tower. These, and the great tower itself, he regards as protrusions of the old volcanic neck of Mont Pelée, dislodged from the place of its original consolidation, and not the production of viscous lava consolidated in situ as it slowly rose from the interior. The latter idea, however, is maintained by the French commission headed by Prof. Lacroix. The author gives abundant evidence to support his idea of the nature and origin of the tower.

The author gives a categorical statement of the wonderful phenomena of this volcanic eruption, comparing it with similar world-known eruptions, and concludes with some reflections on the nature and origin of volcanoes, and the cause of explositions. He discards the idea of the entrance of surface waters to the heated interior of the earth's crust, whether oceanic or land water, and inclines to the idea of magmatic water escaping from the magma and from the hydrated rocks of the interior. His arguments are far from conclusive, but this is not the place to discuss them.

N. H. W.

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PERSONAL AND SCIENTIFIC NEWS.

Geographic Society of Chicago. Professor F. R. Moulton of the University of Chicago gave an illustrated lecture before this society on January 13th. His subject was "What geography owes to astronomy. On February 10th Professor R. D. Salisbury addressed the Society; his subject was "Western mountain scenery."

Mr. C. W. Purington of Denver, accompanied by Mr. Sidney Paige, spent last summer in Alaska in an investigation, for the U. S. Geological Survey, of the methods and costs of placer mining. The report on this subject has been nearly finished. One chapter of this report, dealing with roads and road building in Alaska, will soon be printed as a Senate document. Mr. Purington advocates the building of certain main government roads in Alaska, and he estimates that such roads can be built for from $1,200 to $3,000 per mile, with a yearly cost for maintenance of $350 per mile. These figures are based on the cost of roads that have been built by the Canadian government.

Geological Society of Washington At the meeting of January 11th the following program was presented: "Undulations of certain layers of the Lockport limestone," G. K. Gilbert; "The great fault of the Bitterroot mountains," Waldemar Lindgren; "Artesian water in crystalline rocks," G. O. Smith; "Some erratic boulders in middle Carboniferous shale in Indian Territory," J. A. Taff. At the meeting of January 25th the following program was presented: "Red beds of southwestern Colorado," Whitman Cross and Ernest Howe; "Cause and periods of earthquakes in the New Madrid area, Mo. and Ark.," M. L. Fuller; "Some crystalline rocks of the San-Gabriel range, California," Ralph Arnold and A. M. Strong; "The question of the origin of the natural mounds of Louisiana," A. C. Veatch. At the meeting of February 8th the following program was presented: "Notes on the fossils of the Bahamas," Wm. H. Dall; "Pre-cambrian rocks of the Franklin Furnace quadrangle," A. C. Spencer; "Consanguinity of the eruptive rocks of Cripple Creek," L. C. Graton; "The big sink on the Lucin route across Great Salt Lake," J. M. Boutwell.

Chicago Academy of Sciences. Professor T. C. Chamberlin has been re-elected president for the year 1905. Among the lectures for the winter course of this year are the following: "The Yellowstone National Park," Charles Truax; "The devil fishes and their relatives," F. C. Baker; "The evolution of dogs and cats," S. W. Williston.

Dr. A. S. Packard, celebrated morphologist and geologist of Brown University, died February 14th at 66 years of age.

United States Geological Survey.

Among the recent publications of the Survey are the following:

"Mineral resources for 1903."

"Comparison of a wet and crucible-fire methods for the assay of gold telluride ores, with notes on the errors occurring in the operations of fire assay and parting," by W. F. Hillebrand and E. T. Allen. Bulletin No. 253.

"The southern Appalachian forests," by H. B. Ayres and W. W. Ashe. Professional Paper No. 37.

"Primary triangulation and primary traverse, 1903-4," by S. S. Gannett. Bulletin No. 245.

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"A gazetteer of Indian Territory," by Henry Gannett. Bulletin No. 248.

"Zinc and lead deposits of northwestern Illinois," by H. Foster Bain. Bulletin No. 246.

"Geology of the Perry Basin, Maine," by G. O. Smith and David White, Professional Paper No. 35.

"Rock cleavage," by C. K. Leith, Bull. No. 239.

"The water resources of the Philadelphia district," by Florence Bascom. Water Supply and Irrigation Paper No. 106.

"The geology of the Hudson valley between the Hoosic and the Kinderhook," by T. Nelson Dale. Bull. No. 242.

Bulletin No. 254 is devoted to the Cripple Creek district and contains a summary of facts bearing upon the economic development of this famous gold district. This report is by Waldemar Lindgren and F. L. Ransome and is issued in advance of the final report on the district, which final report will contain detailed descriptions made possible by the resurvey of this area completed last year.

"Economic geology of the Iola (Kansas) quadrangle," by G. I. Adams, Erasmus Haworth and W. R. Crane. Bull. No. 238.

Globe (Arizona) folio, by F. L. Ransome.

Bisbee (Arizona) folio, by F. L. Ransome.

Among the topographic maps recently issued are: Ann Arbor, Mich.; Assiniboine, Havre, Yantic, Chinook, Mont.; Cripple Creek special map, Colo.

Geological Society of Washington. At the meeting on December 14th Mr. G. K. Gilbert presented a paper on "Crescentic gouges on glaciated surfaces."

THE LARGEST DIAMOND EVER FOUND is reported to have been discovered in the Premier mine, South Africa, its weight being about a pound and a half avoirdupois. It is called the New Gem, and its value is estimated at one million dollars, depending on its quality and shape. Its diameter, uncut, is four inches. The diamond called "Brazil" belonging to the court of Portugal, is valued at two million dollars, and is three inches in diameter after cutting, discovered in 1680.

UNPRINCIPLED ASSAYERS. "A word should be added concerning the damage which unscrupulous assayers have inflicted upon the region. With premeditated purpose they have, in many cases, issued false certificates, thus buoying up hope where it already existed, and creating undue excitement. In many cases the unsuspecting miner has been led to continue his search for the metals in the most impossible places. No one thing has contributed more harm to this industry than have these unprincipled assayers." E G. WOODRUFF, *3rd Biennial Report, Oklahoma.*

NEW YORK ACADEMY OF SCIENCES, SECTION OF GEOLOGY AND MINERALOGY. At a late meeting the following entitled papers were read:

"The Serpentines and Associated Asbestos of Belvedere Mountain, Vermont," V. F. Marsters.

"Interpretation of Certain Interglacial Laminated Clays and Their Bearing upon Measurement of Geologic Time," Charles P. Berkey.

"Evolution of Some Devonic Spirifers," A. W. Grabau.

At the meeting of January 9th, Dr. George F. Kunz read a paper on the "Jagersfontein or Excelsior-Tiffany Diamond," the largest diamond ever found up to the present time. It weighed 970 carats, and was a gem of most marvelous purity. This diamond was most expertly cleaved into pieces, and from it were cut ten gems weighing from 13 to 68 carats each; a total of 340 carats; and these were imported into the United States. Mr. Kunz also stated that carbon silicide had been detected in the meteorite from the Canon Diablo by Dr. Henri Moissan, of Paris, together with transparent diamond and black diamond. As carbon silicide has been made artificially with the electric furnace by Messrs. Cowles, Acheson and Moissan heretofore, and was first determined in nature by professor Moissan, if agreeable to Professor Moissan, he would suggest the name moissanite for this compound.

Professor J. J. Stevenson read a paper entitled, "Recent Advances in our Knowledge of the Composition of Coals." He said that the coals of Spitzbergen, according to Nathorst, are in great part of Jurassic age. The mining ope-

rations are confined to Advent bay, a branch of the ice fiord of west Spitzbergen, where coal has been opened on both sides of the bay. The deposit has been followed northwardly for about ten miles, and for an equal distance westwardly.

The chief enterprise is on the easterly side of the bay, where the bed is somewhat less than five feet thick. The coal from the upper part is splint-like, while that from the lower part is brilliant and somewhat prismatic. The divisions show a notable difference in the percentage of volatile, the upper containing about ten per cent more than the lower. The coal shows no tendency to coke, and that from the lower portion is attacked energetically by caustic potash.

The coal was compared with that from other localities in which the benches show notable difference in volatile. The results of tests with caustic potash made upon a number of coals appeared to show that non-coking coals are attacked promptly, while coals yielding a firm coke are not affected even after prolonged boiling.

Professor J. F. Kemp spoke upon "New Sources of the Supply of Iron Ores." Emphasis was first placed upon the enormous demands made by the iron industry of to-day upon the mines of the United States, Great Britain and Germany. The conviction is held by many that within fifty years the local American sources of rich ores of whose existence we now know will be exhausted and the iron masters compelled to seek new deposits. The following possible new districts were passed in review: the Labrador prospects discovered by Mr. A. P. Low, of the Canadian Geological Survey, which might also ship to Europe; Adirondack areas of reported magnetic attraction and possible lean ores, the Temagami district and the Michipicoten range, Ontario; the southern continuation of the Marquette range beneath the drift; the southern half of the Mesabi probable syncline beneath the swamps northwest of Duluth, as suggested by C. P. Berkey; the Baraboo range; the deposits in Iron county, Utah, and in the Wasatch mountains; the magnetites of southern California and the prospects in Washington and along the coast. The speaker emphasized the important reserves in the titaniferous magnetites and their great quantity.

The necessary connection between the coal fields and any great development of the iron and steel industry was emphasized and the future of the three great producers of to-day forecast as involved in the permanency of the coals. The reserves of coal are greater in Germany and America than in Great Britain. The province of Shan-si, China,

having rich stores of both coal and iron, seems to be the one possible new location of the future great iron industry.

Prof. Marsters said: Belvidere Mountain lies approximately along the line between the counties of Orleans, Lamoille and Franklin. It is a sharp crested ridge with a maximum elevation of some 2,100 feet above Eden Corners at its southern termination. Three topographic elements are prominent, a sharp crested ridge forming the upper 900 feet of the mountain, a crescentic plateau with a flat top 1,200 feet above the valley floor and rimming the end of the mountain and lastly a steep slope composing the foot of the plateau and extending to the valley bottom.

The upper part with steep slopes is composed of amphibolite. In addition to the hornblende which make up seventy-five per cent of the rock, there is also present an inconsiderable amount of epidote and a non-pleochroic colorless mineral regarded as zoisite, together with magnetite and pyrite. Towards the base, garnet becomes a prominent constituent, sufficient to make a well-defined garnet zone. In nearly all cases observed, the garnet is largely altered to penninite, a variety of chlorite. Along the garnet zone the hornblende has also undergone marked alteration in part to serpentine. The nose-like projection forming the plateau is composed of serpentine. In this rock occur the so-called asbestus deposits recently prospected and worked for this product. In thin section the serpentine appears to be made up largely of a felty and fibrous mass, apparent only under cross nicols. It is typical fibrous seerpentine. In thin sections from the upper part of the plateau and in close proximity to the overlying amphibolite, there appear shredded masses presenting the original structure of hornblende as seen in the amphibolite, but mineralogically altered to a fibrous mass with the optical characteristics of anthophyllite. It is not improbable, moreover, that a portion of the hornblende has altered to tremolite. These fibrous constituents form the so-called "slip-fiber."

The serpentine belt has also been subjected to peculiar faulting and crushing. The cracks thus produced even on a microscopic scale, have been filled with these fibrous constituents, and then the whole mass submitted to further slipping. This has caused the slickensiding phenomena on the fracture planes and a consequent stretching of the fibrous content; hence the term "slip-fiber." "Cross-fiber" or true chrysotile is to be found in this area. It is best developed along lines of maximum fracture and minimum lateral thrust. There appears to be two bands of maximum fracture, one extending along the upper portion of

the plateau and not far from the garnet zone the second along the foot of the plateau and best shown on the property of Judge Tucker.

The paper of Dr. C. P. Berkey is printed in the Journal of Geology, Jan.-Feb., 1905, vol. 13.

The last paper of the evening was by professor A. W. Bragau, on the "Evolution of Some Devonic Spirifers." Spirifer mucronatus (Conrad) is a Linnæan species comprising a large number of mutations. A remarkable fact is that all mutations pass through a mucronate stage such as is characteristic of the adult mutation after which the species is named. (The term mutation is here used in the sense in which it was originally proposed by Waagen, and not in that in which it was subsequently used by De Vries; i. e., for the result and not for the process.) A still earlier stage in development (nepionic) shows the non-mucronate features of the ancestral species similar to S. duodenarius of the Onondaga. The mucronate feature is carried to excess in a number of mutations of the Lower Hamilton group. It is especially persistent in the Michigan region. This type of outline is accompanied by a rib in the median sinus and a depression in the fold. In Ontario the primitive mucronate type gives rise upward to a number of mutations which are especially characterized by progressive increase in hight without corresponding lengthening of the hinge. The median plication and depression quickly disappear.

Acceleration and retardation in development are the chief principles which explain the development of the great number of mutations. For the principle of retardation the term *bradygenesis* was proposed, corresponding to the term *tachygenesis* proposed by Hyatt for acceleration.

In the New York province the primitive mucronate type gives rise to high and short-hinged mutations, but these retain the median rib and depression. In form these are tachygenetic; in respect to the surface features, bradygenetic. In the arenaceous beds of the later Hamilton in eastern New York, a mutation with many ribs and moderate mucronations exists. This is in many respects a bradygentic type. Side by side with extremely accelerated or tachygenetic types in all horizons (i. e., very short-hinged, non-mucronate, high and thick mutations) occur slightly retarded or bradygenetic types which retain in the adult the mucronate character which is typical of the young of all the mutations.

THE FIELD COLUMBIAN MUSEUM will have the following course of lectures: March 4, "The Explanation of Indian Ceremonies," Dr. G. A. Dorsey; March 11, "Giant Reptiles

of North America, Mr. E. S. Riggs; March 18, "Extinct Mammals of North America," Mr. E. S. Riggs; March 25, "Aims and Methods of Bird Study," Dr. N. Dearborn; April 1, "Hawaiian Cruise of the Albatross," Prof. C. C. Nutting; April 8, "The Fertilization of Flowers by Insects," Dr. F. H. Snow; April 15, "Geographic Factors Involved in the Rise of Chicago," Dr. J. Paul Goode; April 22, "How Rivers and Lakes Became Stocked with Fishes," Dr. S. E. Meek; April 29, "The Basketry of California," Dr. J. W. Hudson.

RECENT STUDY IN SOUTHEASTERN MICHIGAN BY F. B. TAYLOR shows that when lake Maumee was lowered the waters fell to the level of the upper beach of lake Arkona, and that at the close of this lake's existence the ice front re-advanced, pushing the point of discharge up the crest of the "thumb," thereby closing the Arkona outlet and raising the waters to the level of the Belmore beach of lake Whittlesey.

THE GOLDFIELDS DISTRICT, NEVADA, is a new mining camp of much promise, lying about 23 miles south of Tonopah. Mr. J. E. Spurr visited this district in November for the U. S. Geological Survey. The rocks are almost entirely volcanic and are probably of Tertiary age. The ores occur in rhyolytes and andesytes, though no definite vein systems were observed. The outcrops of the quartz bodies are irregular, straggling, branching, and apt to disappear suddenly. They are sometimes nearly circular or crescentic, and frequently are roughly lenticular and intermittent. Owing to the silicification of the volcanic rock in which it occurs, the quartz itself is gray and jaspery. It is probable that this silicification is the work of hot springs and that these irregular reefs represent the horizontal sections of columns of rocks traversed by rising columns of hot water. Had the rocks been strongly fractured we should have had veins like those of the early andesyte at Tonopah, but the lack of such a fracture system at Goldfields resulted in this curious and rather unusual type of deposit. It follows that the quartz reefs will probably extend deeper vertically than horizontally, and so have roughly the nature of columns or pipes. The ores are often of very high grade. As an extreme example may be noted a shipment of 14½ tons from the Sandstorm, which yielded $45,783 net when worked in a stamp mill, while the tailings still contained about $1,000 to the ton. From the McKane-Bowes lease on the Jumbo $600,000 was taken out in five months from a space that measured 100 feet horizontally and 200 feet vertically on the shoot. The whole production of the camp has come from ores that range in value from $200 to $300 a ton. The values are all in gold, as silver is practically absent.

Henry McCalley

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BIOGRAPHICAL SKETCH OF HENRY McCALLEY.*

By EUGENE A. SMITH, University, Alabama.

PORTRAIT—PLATE XIII.

Henry McCalley, who died of pneumonia in Huntsville, Alabama, on November 21, 1904, was born in that city, February 11, 1852. He was the son of Thomas Sanford McCalley of Spottsylvania county, Va., and Caroline, daughter of Robert Landford who built the second house in Huntsville.

Mr. McCalley was one of a family of nine children who reached adult age. He lived at his home two miles west of the court house in Huntsville from his birth to manhood. His school career was begun under the care of Mrs. McKay, then considered the most excellent teacher for young children. From Mrs. McKay he went to Dr. J. M. Bannister, rector of the Church of the Nativity, and afterwards to the noted Mr. Charles Shepard who is still living and engaged in teaching. At the well known school of Dr. Carlos G. Smith he was prepared for college soon after the end of the civil war. As the University of Alabama was at that time in the hands of the "carpet-baggers" and without students, he went to the University of Virginia, from which institution he was graduated in 1876 with the degrees of C. E. and M. E. At the University he applied himself very closely to his studies gaining the highest esteem of both professors and students but sacrificing his health. On his return home after graduation he spent one year on the farm with a view to restoring his health.

* Read at the Philadelphia meeting of the Geological Society of America, 1904.

With the strong recommendation of the faculty of the University of Virginia he took charge of a school at Demopolis, Ala., where he remained one year and part of another. In the summer vacation of 1877 he came to the geological survey of Alabama as a volunteer assistant and traveled with the writer through a part of the Warrior coal field and the valley of the Tennessee. The following year, 1878, Mr. McCalley gave up his school and came to the University of Alabama as assistant in the department of chemistry, then in charge of the writer of these lines. This position he held until 1883, at the same time also serving as volunteer assistant on the Geological Survey, for during the first ten years of the existence of this second survey, the annual appropriation was only $500, none of which went for salaries.

During the summer months of 1879 we had charge of a survey of the Warrior river for the engineer office of the war department under Maj. Damrell, the object of which survey was primarily to ascertain the nature and extent of the obstructions to navigation, and to obtain estimates of the cost of removing or overcoming the same, and secondly to collect statistics of the natural resources of the country lying adjacent to the river.

The levelings and soundings along the river were made under the direction of Mr. McCalley, while the geological data were collected by Mr. Joseph Squire and myself. Our joint report was published in a report of progress for 1879-80. Later in the year Mr. McCalley spent some time in the Tennessee valley and the results of his labors were given in the same report of progress.

In 1883 the Legislature made an appropriation for the Geological Survey which made it possible to employ salaried assistants, and Mr. McCalley then received the appointment as assistant state geologist, which position he held until his death, a period of twenty-one years.

His first work in this capacity was in the Warrior basin on which his first report was published in 1886. This was the first comprehensive statement of the characters and succession of the coal seams of this great field

and it gave great help to those who were engaged in the development of the state.

Next he took up the study of the plateau portion of the Warrior field in northeastern Alabama, and his report on the coal measures of this section was published in 1881.

His next work was in the Paleozoic formations of the Tennessee, Coosa, and other great valleys in which occur the limestones, iron ores, and bauxites of the state and the results of several years work in this section were published in 1896 and 1897 under the title "The Valley Regions of Alabama," part I being devoted to the valley of the Tennessee and part II to the Coosa and other anticlinal valleys, Cahaba, Wills', Jones', and Blount Springs valleys.

The great activity in coal mining during the ten years following the publication of the report of 1886 on the Warrior basin, rendered necessary a reexamination, and more thorough study of the field, and Mr. McCalley spent much time in going again over the ground with Mr. George N. Brewer as an assistant, and in 1890 appeared his report on the Warrior basin, with a large map.

Since 1900 his work has been in the region of the igneous and metamorphic rocks upon which he was engaged at the time of his death. Unfortunately his notes on this region were not written up though quite full and comprehensive. This will make it impossible to get the full benefit of his work.

In personal character Mr. McCalley was modest and somewhat retiring but no one could be more firm and decided than he in the defense of a friend and in the defense of his own opinions on geological matters after he had formed them from his own extended observations. In his scientific work he was careful and painstaking to an extraordinary degree, and his conclusions were rarely hastily formed, and they were in consequence generally correct. He was one of the most truthful of men and he could be relied upon to do to the best of his ability whatever work was assigned to him. When called upon to give his views he did it with the utmost frankness, swerving neither to the right nor the left from the straight path of truth.

In his connection with the survey he was several times called upon to expose frauds; and after he had become convinced on thorough examination of the facts, he left those concerned in no doubt as to his conclusions and convictions.

He was a consistent and active member of the Episcopal church and very generous in his support of it, responding cheerfully to all the calls made upon his time and means.

It is said of him that as a child and a young boy he had never received a correction from either parent or teacher and he never neglected a task set before him; these characteristics followed him through life.

Mr. McCalley was a member of the American Association for the Advancement of Science; fellow of the Geological Society of America; member of the American Institute of Mining Engineers; secretary of the Alabama Industrial and Scientific Society, etc.

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THE NEBULAR AND PLANETESIMAL THEORIES OF THE EARTH'S ORIGIN.*

By WARREN UPHAM, St. Paul, Minn

Astronomy and geology, chemistry and physics, with their very useful arm or ally, spectroscopy, seek together to discover the origin and development of the earth and the moon, of the sun and his retinue of planets, and of the starry universe:

> "In the beginning how the heavens and earth
> Rose out of chaos."

While we are assured that they "declare the glory of God," and that "all things were made by Him," it has also been learned not less surely that He has worked by His established physical and chemical laws in the creation of suns and worlds. We may partially discern the laws, or methods of working, through which the Creator has made and upholds the myriads of stars and our relatively small but yet vast solar system; but beyond all that we know, as, for example, of the laws of gravitation, everywhere lies mystery which baffles our comprehension. How all matter is influenced by all other matter and drawn toward it, how the earth began and came to its present condition, how the crystal or the plant or the animal grows, "great things and unsearchable, marvelous things without number," proclaim an omnipresent and omnipotent Creator and Ruler.

To learn continually more and more of His thoughts, as revealed in His works, is the highest reward of the student of nature; and increased powers of vision, whether with the telescope or the microscope, open ever widening fields of knowledge and new problems to be solved. In every direction the search for truth reaches no limit; and in the themes of this paper, although much has been ascertained, infinitely more remains for inquiry.

The nebular hypothesis or theory may well be called the grandest generalization in all the range of the natural sciences. As most elaborately stated by the eminent astronomer and mathematician, Laplace, in his *Mechanique Celeste* (published in five volumes, 1799-1825), this theory

* Presented before the Victoria Institute, London, March 20, 1905.

traces the beginning and development of the solar system from an original gaseous nebula, an exceedingly tenuous and intensely heated cloud of matter, extending in a spheroidal form beyond the orbit of Neptune, the outermost planet. By its gravitation and resulting contraction, the nebula is supposed to have acquired a movement of rotation, with polar flattening. Whenever the outer equatorial belt of the revolving nebula attained a centrifugal force exceeding the attraction toward the central mass, a part would be left behind, either as a relatively small revolving nebulous body, or as a ring of such matter, somewhat like the rings of Saturn. Later the ring, if it was at first of that form, would be broken; and finally the detached mass would be gathered into a globe, which, in its condensation, would form satellites in the same manner as outer parts of the great central mass formed the successive planets.

Under this theory the principal features of our planetary system, implying unity of origin and development, find a consistent general explanation. Prof. Charles A. Young has enumerated these features, which could only have originated by some process of orderly evolution, as follows:*

1. The orbits of the planets are all *nearly circular*.

2. They are all nearly in *one plane* excepting considerable divergence of some of the little asteroids.

3. The revolution of all is *in the same direction*.

4. There is a curiously *regular progression of distances* between the planetary orbits.

5. There is a roughly regular *progression of density*, increasing both ways from Saturn.

6. The plane of the planets' rotation *nearly coincides with that of the orbits*.

7. The direction of the rotation *is the same as that of the orbital revolution* excepting probably the two outermost planets.

8. The *plane of orbital revolution of the satellites* is nearly coincident with that of the planet's rotation.

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* Text-Book of General Astronomy, 1898, p. 515.

9. The *direction* of the satellites' revolution also coincides with that of the planet's rotation.

10. The largest planets rotate most swiftly.

That these wonderfully harmonious relations of the planets to each other and to the sun, and of the satellites to the planets, could have originated by any fortuitous concourse of matter, like the visits of comets which may come from any part of the heavens, is utterly improbable. There is not one chance in millions for the order of the solar system to have come to pass without a systematic development; but the sublime theory of Laplace, in its main outlines, with modifications as required by further knowledge of astronomical and physical laws, or some other nebular theory, perhaps the one most fully reviewed in this paper, accounts for all this majestic unity of the Creator's plan in launching the earth and its associate planets to revolve around the enormously larger central sun.

Instead of an originally gaseous and very hot condition of the parent nebula, as supposed by Laplace, some prominent English physicists and astronomers have thought that in its earliest definable condition it consisted of meteorites, that is, particles and little masses of solid and cold matter. Sir Norman Lockyer, reasoning from his extensive investigations in spectrum analyses, states this view as follows:* "Nebulæ are really swarms of meteorites or meteoritic dust in the celestial spaces. The meteorites are sparse, and the collisions among them bring about a rise of temperature sufficient to render luminous some of their chief constituents."

Besides the testimony of the spectroscope concerning the characters of the nebulæ, we may consider the rings of Saturn, which are very thin but have great areal extent, as probably a strong evidence of the meteoritic derivation of the planets and the sun. Richard A. Proctor, after stating the physical impossibilities of the existence and permanence of these unique rings as either solid or liquid continuous bodies, wrote:† "The sole hypothesis remains

* The Meteoritic Hypothesis, a Statement of the Results of a Spectroscopic Inquiry into the Origin of Cosmical Systems, 1890, p. 222.

† Saturn and its System, second edition, revised, 1882, p. 126.

that the rings are composed of flights of disconnected satellites, so small and so closely packed that, at the immense distance to which Saturn is removed, they appear to form a continuous mass." In other words, the Saturnian rings are made up of myriads of separately moving small masses, which are doubtless similar to the stony meteorites that fall rarely on the earth.

Again, the origin of the hundreds of asteroids, or minor planets, mostly no more than a few miles in diameter, but including several from 100 to perhaps about 300 miles in diameter, seems very readily explained under this modification of the nebular theory.

Professor Young well says:* "The *meteoric* theory of a nebula does not in the least invalidate, or even to any great extent modify, the reasoning of Laplace in respect to the development of suns and systems from a *gaseous* nebula. The old hypothesis has no quarrel with the new."

Another theory, which differs more widely from that of Laplace, has been very recently proposed by Prof. T. C. Chamberlin, of the University of Chicago, who names it the Planetesimal Hypothesis. His studies in this direction have been in progress about five years, with publication of preliminary papers,† preparing the way for the new hypothesis; but its first somewhat detailed statement in print has appeared since the beginning of the present year.‡ In this latest paper, Professor Chamberlin gives the following principal outlines of his researches for a new and more applicable nebular theory, especially having in view its relation to the origin of the earth.

Under the typical form of the planetesimal hypothesis it is assumed that the parent nebula of the solar system consisted of innumerable small bodies, planetesimals [infinitesimal planetoids], revolving about a central gaseous mass, somewhat as do the planets to-day. The hypothesis, therefore, postulates no fundamental change in the system of dynamics after the nebula was once formed, but only an assemblage of the scattered material.

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* Text-Book of General Astronomy, p. 526.

† An Attempt to Test the Nebular Hypothesis by the Relations of Masses and Momenta, in the Journal of Geology, Chicago, vol. viii, pp. 58-73, Jan.-Feb., 1900. On a Possible Function of Disruptive Approach in the Formation of Meteorites, Comets, and Nebulae, Journal of Geology, vol. ix, pp. 369-392, July-August, 1901.

‡ Fundamental Problems of Geology, in the Year Book No. 3, for 1904, of the Carnegie Institution of Washington, published in January, 1905, pp. 195-258.

An inquiry into the possible modes by which the planetesimal condition might arise revealed several possible methods. Such condition might arise from a nebula that was originally gaseous. If. for example, it be supposed that the parent nebula was a gaseous spheroid, and that it detached material from its equatorial belt molecule by molecule, rather than by rings, as postulated by Laplace, these molecules would probably become planetesimals instead of members of a true gaseous body. * * * There is reason to believe that this method would really be almost the only systematic one by which a gaseous spheroid of the Laplacian type would detach material from its equatorial belt. * * *

* * * To develop the hypothesis as definitely and concretely as possible, I have further chosen a special case from among those that might possibly arise, the case in which the nebula is supposed to have arisen from the dispersion of a sun as a result of close approach to another large body. The case does not involve the origin of a star nor even the primary origin of the solar system, but rather its rejuvenation and the origin of a new family of planets. * * * This particular sub-hypothesis was selected for first development (1) because it postulates as simple an event as it seems possible to assign as the source of so great results, (2) because that event seems very likely to have happened, (3) because the form of the nebula supposed to arise in this way is the most common form known, the spiral, and (4) because spectroscopic observations seem at present to support the constitution assigned this class of nebulæ. * * *

* * * The continuous spectrum is interpreted to mean that their chief luminous material is in a liquid or solid state. * * * As the liquid condition is limited to a rather narrow range of temperature, and as this range is very different for different material, it is improbable that any large portion of a nebula is in this state, and the whole may be conveniently treated as though it were formed of solid matter, but matter in a fine divided condition. This last qualification seems necessary, for the volume of these nebulæ is often very great, and yet they appear to intercept but little light and give no signs of great attractive power.

The prevailing form of these nebulæ is the *spiral* as determined by the late Professor Keeler, and this form particularly characterizes the smaller nebulæ recently brought to knowledge by improved instruments and manipulative skill. These newly discovered nebulæ are estimated to number at least ten times the whole number previously known. From the superior number of spiral nebulæ it is a safe inference that their peculiar forms represent some prevalent process in celestial dynamics. This is in itself a reason why research should turn to them, by preference, for the origin of the present solar system. * * *

A notable and seemingly very significant feature of these

nebulæ is the presence of *two dominant arms* that arise from diametrically opposite sides of the nucleus and curve concentrically away. No single-arm spiral of the watchspring type has been found, so far as I am aware. There are often more than two arms in the outer part, and there is much irregularly dispersed matter, but even in the more scattered forms the dominance of two arms is discernible.

A second feature of note is the presence of numerous *nebulous knots* or partial concentrations on the arms and more or less outside them. So, also, the more diffuse nebulous matter is unequally distributed, and in some of the forms, regarded as youngest, dark spots and lines emphasize the irregularity.

All these features go to show that these forms are controlled, not by the support of part on part, as in a continuous body or in a mass of gas or even in a definite swarm of quasi-gaseous meteorites, but by some system of combined kinetic energy and gravity which *permits independence of parts.* It is, therefore, conceived that the innumerable solid or liquid particles which the continuous spectrum implies revolve about the common center of gravity as though they were planetoidal bodies. If this were certainly known to be the case, these might well be called *planetesimal nebulae.*

It is clear from the tenuity of these nebulæ, as seen from the side of the spiral, that they are disk-like, and this is directly shown to be so when they are seen obliquely. In their disk-like shape, these nebulæ conform to the mode of distribution of matter in the solar system. Within the area of their disks, also, the distribution is irregular, as it is in the solar system—a fact too much overlooked by reason of our predilection for symmetry, under the influence of the symmetrical Laplacian conception.

All of the more familiar spiral nebulæ have dimensions that vastly transcend those of the solar system, and they cannot be taken as precise examples of the solar evolution. * * * It is to be hoped, however, that the present rapid progress in the perfection of instruments and of skill will soon bring within the reach of successful study some of the smaller spiral nebulæ that represent the solar system more nearly in mass and proportions.

With this much of knowledge and of limitation of knowledge relative to existing nebulæ, the construction of a working hypothesis required not a little resort to supplementary deductive and hypothetical considerations. The inference that a spiral nebula is formed by a combined outward and rotatory movement implies a pre-existing body that embraced the whole mass. In harmony with this, an ancestral solar system has been postulated —a system perhaps in no very essential respect different from the present one. * * *

To this conception of an ancestral sun with an undefined antecedant history as a star, question will arise at once as to a

sufficiency of energy for the sun's maintenance through such a prolonged history. * * * This objection is based on the assumption that the sun's heat and light are derived *almost wholly* from self-compression, as urged by Helmholtz. This self-compression has usually been computed on the basis of certain limiting assumptions, the validity of which is open to question. * * * The extraordinary energies displayed by radio-active substances are doubtless but an initial demonstration of immeasurable energies resident in other forms of matter and in the constitution of the sidereal system and competent for its maintenance for unassignable periods. * * *

* * * No appeal is here made to collisions as a source of the parent nebula of the solar system, but only to an approach of the ancestral sun to another large body, and this approach is not assumed to have been very close. * * *

Our present sun shoots out protuberances to heights of many thousands of miles, at velocities ranging up to 300 miles per second and more. If it were not for the retarding influence of the immense solar atmosphere, some of these outshoots would doubtless project portions of themselves to the outer limits of the present system, and perhaps in some cases quite beyond it, for the observed velocities sometimes closely approach the controlling limit of the sun's gravity, if they do not actually reach it. * * * If with these potent forces thus nearly balanced the sun closely approaches another sun or body of like magnitude—suppose one several times the mass of the sun, since it is regarded as a small star—the gravity which restrains this enormous elastic power will be *relieved along the line of mutual attraction*, on the principle made familiar in the tides. At the same time the pressure transverse to this line of relief is increased. Such localized relief and intensification of pressure must, it is believed, result in protuberances of exceptional mass and high velocity. According to the well-known tidal principle, these exceptional protuberances would rise from opposite sides, and herein lies the assigned explanation of the prevalence of two diametrically opposite arms in the spiral nebulæ.

Nothing remotely approaching a general dispersion of the ancestral sun seems to be required. The present planets and their satellites altogether amount to about one seven-hundredth part of the mass of the system. Simply to supply the required planetary matter, the protuberances need include but this small fraction of the ancestral sun. However, some considerable part of the projected matter must probably have been gathered back into the sun, and some part may possibly have been projected beyond the control of the system. Making allowances for both these factors, the proportion of the sun's mass necessarily involved in the protuberances is still very small. Apparently 1 or 2 per cent of the sun's mass would amply suffice. * * *

The distal portions of the protuberances would obviously be formed from the superficial portions of the sun, while the later portions of the ejections forming the proximal parts of the arms would doubtless come mainly from lower depths, and hence probably contain more molecules of high specific gravity. In this seems to lie a better basis for explaining the extraordinary lightness of the outer planets and the high specific gravities of the inner ones, than in the separation, from the extreme equatorial surface of a gaseous spheroid, of successive rings whose total mass only equaled one seven-hundredth part of the original nebula.

It seems consistent with the conditions of the case to assume that the protuberances would consist of a succession of more or less irregular outbursts, as the ancestral sun in its swift whirl around the controlling star was more and more affected by the latter's differential attraction; and hence the protuberances would be directed in somewhat changing courses, and would be pulsatory in character, resulting in rather irregular and somewhat divided arms, and in a knotty distribution of the ejected matter along the arms. These knots must probably be more or less rotatory from inequalities of projection.

It is thus conceived that a spiral nebula, having two dominant arms, opposite one another, each knotty from irregular pulsations, and rotatory, the knots probably also rotatory, and attended by subordinate knots and whirls, together with a general scattering of the larger part of the mass in irregular nebulous form, would arise from the simple event of a disruptive approach. * * *

The problem of the luminescence of nebulæ is confessedly a puzzling one. There is little ground for assigning general incandescence to matter so obviously scattered and tenuous and possessed of such an enormous radiating surface. The assignment of the light to the collision of meteorites, as done by Lockyer, encounters both dynamic and spectroscopic difficulties. The recent discoveries of the luminescent properties of radioactive matter and of its power to awaken luminescence in other matter offers some hope of a solution. * * *

The solution of the problem may, however, lie along electrical lines. At present it seems more probable that the luminescence arises from some agency that acts at low temperatures, than that it is dependent on heat, and hence objections to a planetesimal organization on the ground of low temperature do not seem to me to have much force. * * *

In attempting to follow the probable evolution of such a spiral nebula, three elements stand out conspicuously: (1) The central mass, obviously to become the sun; (2) the knots on the arms that are assumed to be the nuclei of the future planets and perhaps satellites; and (3) the diffuse nebulous matter to be added to the nuclei as material of growth. In the particular case of the

solar nebula it is assumed (1) that the central mass was relatively very great; (2) that the knots were very irregular in size and placed at irregular distances from the center; and (3) that the nebulous portion was very small relative to the central mass and probably large relative to the knots.

* * * Since all the planetesimals and planetary nuclei were revolving *in the same direction* about the solar mass, the collisions were all overtakes, and could have been violent only to the extent of their differences of orbital velocity, modified by their mutual attractions. These velocities are of a much lower order than the average velocities of meteoritic collisions. Many of the overtakes would obviously be due to differences of velocity barely sufficient to bring about an overtake. When the relative mildness of impact is considered in connection with the intervals between impacts at a given spot, the conviction can scarcely be avoided that *the surface temperature would not necessarily have been high.* It seems probable that it would have been moderate throughout most of the period of aggregation, and certainly so in the declining stages of infall. * * *

By graphical inspection of all probable cases, it may be seen that the possibilities of overtake favorable to forward rotation exceed those favorable to retrograde rotation. This holds true on the assumption of an equable distribution of planetesimals, which may fairly be assumed as an average fact, but not necessarily as always the fact; and hence the conclusion is not rigorous, and a backward rotation is not impossible. From the nature of the case, a varying rotation for the several planets is more probable than a nearly uniform one.

It is also obvious that the impacts on the right and left sides of a growing nucleus, as well as those on the outer and inner sides, might be unequal, and hence *obliquity* of rotation of varying kinds and degrees might arise. As the solar system presents these variations, the method of accretion here postulated seems to lend itself happily to the requirements of the case.

* * * A planetary nucleus gathers planetesimals that have orbits both larger and smaller than itself, and hence in effect it sweeps a space both outside and inside its own zone. The breadth of this space is dependent on the eccentricity of its own orbit and on the eccentricities of the orbits of the planetesimals it gathers in on either hand.

* * * For the large planets that have dominated their collecting zones and presumably swept them thoroughly, the reductions of eccentricity are subequal. For the very small bodies that presumably grew but little, *the eccentricities remain large,* for the greater part. For example, the eccentricity of Mercury, the smallest of the planets, remains more than twice that of any other planet. Mars, the next smallest in size, comes next in eccentricity among the planets, while the asteroids, which probably

grew but little, have high eccentricities, as a rule. * * *

To bring out the geological bearings of the planetesimal hypothesis, I have given considerable time to a study of the probable stages of growth of the early earth, of the time and mode of introduction of the atmosphere and hydrosphere, and of the initiation of the great topographic features, together with the leading modern processes. * * *

Following the postulates of the previous sketch, a nebular knot is assumed to have been the nucleus of the growing earth. * * * Assuming that the nuclear mass was quite small, it is inferred that it was composed chiefly of matter of high molecular weight, since light molecules would be liable to escape because of their velocities. The nucleus is supposed to have been originally an assemblage of planetesimals grouped together by their mutual gravity, and to have passed gradually into a solid mass in connection with the capture of outside planetesimals. * * *

As the solid nucleus thus formed may not have been massive enough to control a gaseous envelope in its earlier stages, a possible atmosphereless stage is to be recognized. Just how massive a planetary body must be to hold permanently an appreciable atmosphere is not accurately computable at present, because of the uncertain value of some of the factors involved. A fairly safe conclusion may perhaps be drawn from known celestial bodies. The moon * * * has no detectable atmosphere, nor has any smaller body, whether satellite or asteroid, so far as known. Mars * * * has an appreciable, but apparently quite limited, atmosphere. The limit between atmosphereless and atmosphere-bearing bodies probably lies between the two—*i. e.*, roundly between one-eightieth and one-tenth of the earth's mass. * * *

When the growing earth reached a mass sufficient to control the flying molecules of atmospheric material, there were two sources from which these could be supplied for the accumulation of an atmosphere, an external and an internal one. * * *

In the later stages of organization, and thence down to the present time, the molecules discharged from all the bodies of the solar system were possible sources of atmospheric accretion. Of these the most important were probably volcanic and similar discharges from the small bodies that could not hold gases permanently and discharges from the sun by virtue of the enormous explosive and radiant energies that are there resident.

As the planetesimals were gathered into the growing earth-nucleus they carried their occluded gases in with them, except as the superficial portion might be set free by the heat of impact. There was thus built into the growing earth atmospheric material. * * *

The gases chiefly occluded in meteorites and the crystalline rocks are hydrogen, carbon dioxide, and carbon monoxide in

leading amounts, and marsh-gas and nitrogen in small quantities. It is assumed that the gases of the aggregated planetesimals, and hence those of the interior of the early earth, were of the same order of abundance. * * *

In determining the actual proportions of the constituents of the early atmosphere, the abundance of the supply was probably less decisive than the power of the earth to hold the individual gases. As gravity gradually increased by the growth of the earth from an incompetent minimum, its power to control the heaviest molecules with the lowest velocities was acquired before its ability to hold the lighter ones of higher velocities. * * *

Carbon dioxide would be held some appreciable time before oxygen, and still longer before nitrogen, and all these a notable time before the vapor of water. The inference is that the initial atmosphere was very rich in carbon dioxide, for an abundant supply was correlated with a superior power of retention.

The amount of oxygen in the early atmosphere is more uncertain from doubt as to a competent source of supply. * * * For the primitive atmosphere there is theoretical need for only enough oxygen to support the primitive plant life until it could supply itself, after which it would produce a surplus. * * *

After the earth acquired the power of holding water-vapor, the supply being abundant, accession doubtless went on for a time as fast as the capacity to hold increased.

The problem of vulcanism assumes a quite new aspect under the planetesimal hypothesis, if very slow accretion without very high temperature be assumed. It has been taken for granted in the preceding statement that there was volcanic action. It is necessary, therefore, to consider how volcanic action may have arisen, and this involves the more radical question how the high internal temperatures of the earth may have arisen if the earth did not inherit its heat from a molten condition arising from a gaseous origin. * * *

The chief source of internal heat is assigned to the progressive condensation of the growing body as material was added to its surface. The amount of this condensational heat for the full-grown earth, computed on the best data now available, seems to be ample to meet all the requirements of the known geologic ages. * * * That heat arising from condensation *solely* would reach the melting temperature of rock in a body one-twentieth of the earth's mass seems more or less doubtful, but in a body one-tenth of the earth's mass the required conditions would probably be reached. * * *

Pressure itself is probably incompetent to melt rock substances that shrink in solidifying, but the high temperatures generated by pressure in the deep interior were constantly moving outward into horizons of lower pressures, where the melting-points were lower. As the computed temperature at the center

of the adult earth is about 20,000° C., there would seem to be no lack of heat, in the later stages at least. The essence of the problem lies in its redistribution and in its selective action.

The material of the interior was originally, by hypothesis, an intimate mixture of planetesimals of various kinds, with such gaseous material as they carried in or entrapped in the process of growth. * * * The outward flow of heat in such a mixture must bring some parts to fusibility much before the melting-points of other parts were reached. Local spots of fusion must thus arise. To this fusion the entrapped and occluded gases may be presumed to have contributed and to have joined themselves to the fused masses, and to have aided in giving them fluidity. * * *

It is not necessary to the hypothesis to suppose that volcanic action was an essential preliminary to the acquisition of an atmosphere, nor that it came into function before the earth acquired an atmosphere, for the initial atmosphere may have been supplied from external sources. The apparent vigor and the wide prevalence of volcanic action on the moon, if its pitted surface means vulcanism, as well as the glassy material found in meteorites, whose origin is referred preferably to small atmosphereless bodies, favors the view that the internal gases were given forth abundantly before the earth grew to a mass sufficient to hold them. If this were true, an ample source of atmospheric supply was ready and waiting when the earth first acquired sufficient gravity to clothe itself with a gaseous envelope.

When the increasing water-vapor of the growing atmosphere reached the point of saturation, it is of course assumed to have taken the liquid form and became a contribution to the hydrosphere. * * *

If it be assumed that the earth's growing hydrosphere appeared at the surface when our planet had attained the mass of Mars, whose radius is about 2,100 miles, the subsequent growth would form a shell about 1,900 miles thick. It is not altogether certain that Mars bears water bodies on its surface; but the areas of greenish shade environed by a surface generally ruddy, the polar white caps ("snow caps") that come and go with the seasons, and the apparent occasional presence of clouds, not to appeal to the evidence of aqueous absorption lines in the spectrum reported by some good observers, but unconfirmed by others, lend some support to the opinion that water is present, though perhaps not in the form of definite water bodies. * * *

Without attempting to fix the precise stage, it is not unreasonable to assume that surface waters had begun their accumulation upon the earth's exterior while yet it lay 1,500 to 1,800 miles below the present surface. The present difference between the radii of the oceanic basins and the radii of the continental platforms is scarcely 3 miles, on the average; so that if the continental segments be assumed to be in approximate hydrostatic

equilibrium with the oceanic segments to-day, as seems highly probable, the selective weathering process brought about a difference in depression of only 1 mile in 500 or 600 miles, or about one-fifth of 1 per cent. * * *

Not only is the evolution of the great abysmal basins and of the continental platforms thus assigned to a very simple and inevitable process, but there is therein laid the foundation for subsequent deformation of the abysmal and continental type.

* * * A theoretical scantiness of time for a prolonged evolution previous to the Cambrian period has been deduced from a molten earth, but this does not apply to the planetesimal hypothesis. The supposed limitation of the sun's thermal endurance would apply if the arguments could be trusted, but their foundation has been cut away by recent discoveries. It is not the least of the virtues of the planetesimal hypothesis that it opens the way to a study of the problem of the genesis and early evolution of life free from the duress of excessive time limits and of other theoretical hamperings, and leaves the solution to be sought untrammeled, except by the conditions inherent in the problem itself, which are surely grave enough.

It is assumed that the conditions on which life is now dependent were prerequisites to its introduction. As already indicated, an atmosphere and hydrosphere sufficient to sustain life may have been acquired when the earth was about the size of Mars, or one-tenth grown. If, to be conservative, a preliminary growth of twice this amount be allowed, there still remains between this and the Cambrian record the growth of four-fifths of the mass of the earth. So far, therefore, as atmosphere and hydrosphere are concerned, life may have been introduced early in the history of the earth, and may have had a vast interval for development previous to the earliest legible record. There is another essential condition—a sufficiency, but not an excess, of heat and light. If the formation of the parent nebula involved only the outshooting of a small fraction of the ancestral sun, the solar supply of heat and light may not have been so seriously disturbed as to have fatally affected its availability to furnish what was necessary for life at any stage of the earth's growth. * * *

* * * There is little ground for apprehension that the infalling planetesimals would be seriously dangerous to the early forms of life, for in the first place the atmosphere must have been then, as now, an effective cushion, checking the speed of the planetesimals and partially dissipating them, and, in the second place, the early organisms were probably all aquatic and were further protected by their water covering. * * *

So soon as plants and animals had come into action, all the great factors potential in the earth's physical evolution were in play.

By hypothesis, volcanic action only began some time after the beginning of the earth's growth, for it was delayed (1) by the

lack of sufficient compression in the central parts to give the requisite heat, and (2) by the time required for this central heat to move out to zones of less pressure, where it would suffice to melt the more fusible constituents. But, once begun, it is supposed to have gradually increased in actual and in relative importance until it reached its climax. This obviously came much later than the climax of growth, for it was dependent on the growth to give the increased compression from which arose the central heat on which the vulcanism depended. * * *

The formations of this period of volcanic dominance, with very subordinate clastic accompaniment, are regarded as constituting the Archean complex, though perhaps only the later portions of the great volcanic series are represented by the known Archean.

To give a satisfactory statement of Professor Chamberlin's exceedingly interesting and elaborate theory has thus required very large quotation from his recent publication of it. Only by such direct presentation of his work in his own words could justice be done to this new nebular theory, to which this eminent glacialist was primarily led by his endeavors to explain the causes of the Ice Age, and of its several waxing and waning stages, by periodic changes in the content of carbon dioxide in the atmosphere. Having been an assistant under his direction on the United States Geological Survey during seven years in my work on the Glacial Lake Agassiz, it is with great pleasure and pride that I can claim for him and for America the distinguished honor of having developed this great theory of the origin of the earth. It will certainly introduce into geology and geophysics many new and fruitful methods of observation and research. Indeed, nearly all the great fields of theoretical geology now require renewed investigation, by which the planetesimal hypothesis shall be tested.

An earlier address by Professor Chamberlin, partially setting forth his studies in this direction, was given before the Geological Society of America, at its fifteenth annual meeting, in Washington, D. C., on January 1, 1903, entitled "Origin of Ocean Basins on the Planetesimal Hypothesis;" but only a very brief abstract or note of this address was published.*

* Bulletin, Geol. Soc. America, vol. xiv, p. 548, March, 1904; and AM. GEOLOGIST, vol. xxxii, p. 14, July, 1903.

From the oral statements in this and other unpublished addresses, Prof. Herman L. Fairchild, secretary of the Geological Society of America, presented on January 1, 1904, at the sixteenth annual meeting of that society, an able discussion of the geologic bearings of the new hypothesis.*

The recent detailed publication of it, in Year Book No. 3 of the Carnegie Institution, from which I have so largely quoted, has no diagrams or other graphic illustrations; but such desirable aids for the more definite development of the subject, with ample treatment of its relations to geology, are intended to be published soon, in the second volume of a geological text-book by Professors T. C. Chamberlin and R. D. Salisbury, whose first volume of this work was issued early last year.†

Chamberlin has contributed greatly to the establishment of an acceptable nebular theory, consistent with the known relations of the planets, their satellites, and the sun, by his derivation of the solar system from a spiral nebula, and by his indicating the probable mode of origin of such nebulæ, which abound by tens of thousands throughout the starry heavens, as discovered by the most powerful telescopes.

Both the meteoritic hypothesis of Lockyer and the planetesimal hypothesis of Chamberlin seem to me probably true in their regarding the nebulous matter from which planets and suns are made as having become mostly solid, though finely divided, and as very cold, being in almost absolutely cold and immensely extended space, previous to the condensation and segregation which formed it into worlds and stars.

During the accumulation of the planets and their satellites, much or perhaps nearly all of the nebulous matter forming them had remained, until thus gathered as great bodies, apparently in solid and cold molecules or in small masses brought together by their gravitative at-

* Geology under the Planetesimal Hypothesis of Earth-Origin, Bulletin, G. S. A., vol. xv, pp. 243-266, published June 23, 1904; and AMERICAN GEOLOGIST, vol. xxxiii, pp. 94-116, Feb., 1904.

† Geology. In Two Volumes. Vol. 1. Geologic Processes and their Results. New York, Henry Holt and Co., 1904. Pages xix, 654.

traction, as seems reliably evidenced by the rings of Saturn and by the many little asteroids.

Coming to the question whether the accumulation of so large a body as the earth took place without its becoming intensely hot and molten, somewhat like the sun, we have first the observations and theories of geology to aid in giving an answer, and these may be advantageously supplemented by the physiographic features of our satellite, the moon. It has been long held by geologists that the downward increase of heat in the earth's crust, present volcanoes, the widely distributed evidences of ancient volcanic action, and thermal metamorphism of great rock formations, indicate an internal temperature which must fuse any known rocks, unless they are prevented from this by overlying pressure. The new hypothesis of Chamberlin accounts for vulcanism, and for all that we know of the earth's internal heat, fully as well as the Laplacian hypothesis of condensation of an intensely hot gaseous nebula, while it better accords with the physical and dynamic relations of the planets and sun.

If our inquiry be turned to the moon, we see a most wonderful record, as it is generally regarded, of extinct volcanic action, implying a formerly very hot and probably almost wholly molten state of that globe, which has a little more than one-fourth the diameter of the earth. These two companion globes were doubtless accumulated similarly. The moon, after acquiring its present size, had multitudes of volcanoes which left round craters, or parts of their crater rims, of varying dimensions from those at the limit of telescopic vision up to one with a diameter of about 800 miles, or nearly four-fifths of the moon's radius. So great a lake or sea of molten rock, similar to the calderas of the Hawaiian volcanoes, but of vastly larger area, whose crater rim is partially preserved in the lunar Carpathian-Apennine-Caucasus chain of mountains, could only exist when much of the interior of the moon was melted. It seems possible and indeed probable, therefore, that the earth, whether formed as supposed by the old or the new nebular hypothesis, was nearly or quite all melted during a considerable part of the time of its accumulation.

The planets undoubtedly tended in some degree toward the same intensely hot condition which is reached by the sun and stars in the concentration of originally nebulous matter.

But another explanation of the origin of the very abundant small and large crateriform features of the moon has been advocated by G. K. Gilbert, of the United States Geological Survey. This very remarkable and ingenious explanation seems largely identical with the later planetesimal hypothesis of Chamberlin, so far as that hypothesis deals with the segregation of the originally nebulous matter to form planets and satellites. Mr. Gilbert writes:*

* * * It is my hypothesis that before our moon came into existence the earth was surrounded by a ring similar to the Saturnian ring; that the small bodies constituting this ring afterward gradually coalesced, gathering first around a large number of nuclei, and finally all uniting in a single sphere, the moon. Under this hypothesis the lunar craters are the scars produced by the collision of those minor aggregations, or moonlets, which last surrendered their individuality.

* * * The introduction of the hypothesis of a Saturnian ring thus accomplishes much toward the reconciliation of the impact theory with the circular outline of the lunar craters. * * *

In fine, the hypothesis of the Saturnian ring, by restricting the colliding bodies to a single plane, by substituting a low initial velocity and thus rendering the moon's attraction the dominant influence, and by introducing a system of directions controlling, and therefore adjusted to, the moon's rotation, relieves the meteoric theory of its most formidable difficulty. It also explains in a simple way the abundance of colliding bodies of a different order of magnitude from ordinary meteorites and aerolites. * * *

The velocity of impact, depending chiefly on the moon's attraction, must be supposed to have increased gradually as the

* The Moon's Face, a Study of the Origin of its Features, Address as Retiring President, delivered December 10, 1892, Bulletin of the Philosophical Society of Washington, D. C., vol. xii, pp. 241-292, with one plate and 14 figures in the text; published April, 1893.

Referring to early suggestions of meteoric accumulation of the moon, and of other cosmic bodies, Mr. Gilbert said in this paper (1892): "I have discovered no published statement of meteoric theories more than twenty years old, but the idea is older and various obscure allusions indicate that it was earlier in print. Proctor makes a meteoric suggestion in 1873 (The Moon, p. 346), and advocates it in 1878 (Belgravia, vol. 36, p. 153). A meteoric theory is said to be contained in *Die Physiognomie des Mondes* by 'Asterios,' Nordlingen, 1879. A. Meydenbauer advances another in Sirius, for February, 1882."

With these publications, compare The Meteoritic Hypothesis, 1890, by Lockyer, before cited, and a most important paper by Prof. George H. Darwin, "On the Mechanical Conditions of Swarms of Meteorites and on Theories of Cosmogony," Phil. Trans. Royal Society, 1888.

moon grew. In the closing stages of the process it did not vary greatly on either side of one and one-half miles per second, and the phenomena of the present surface may be discussed on the basis of that velocity. The energy due to that velocity would more than suffice * * * to melt the moonlet if it were composed of ordinary volcanic rock and provided all of the energy were applied to the heating of the moonlet. Practically only a portion of it was thus applied; another portion produced heat in the contiguous tract of the moon's material; yet another was consumed in the deformation of moonlet and moon resulting in the crater, and another resulted in modifications of the moon's motions, changing its orbit, its orbital velocity, its axis, and its rotational velocity. The energy converted into heat might be regarded as the remainder after deducting all other effects, and the resulting temperatures would be further conditioned by the distribution of heat in the colliding masses.

Since the area of the moon's surface directly struck by the moonlet is a function of the square of the diameter of the moonlet, while the energy applied to that area, being measured by the mass of the moonlet, is a function of the cube of its diameter, more energy would be applied to a unit of space in the case of large moonlets than in the case of small, and the temperatures caused by large moonlets would therefore be greater. To this relation I ascribe the restriction of inner plains, indicative of fusion, to the larger craters. * * *

In the breaking up of the postulated pre-lunar ring there were at first many centers of aggregation,—were the moon the only center, the scars of impact would all be small. So long as the masses were small the process of aggregation developed little heat, for the heat of impact depended almost wholly on velocities created by mutual attractions. That particular moonlet which became the nucleus of the moon may therefore be conceived as cold, or at least as sufficiently cool to be solid. As the moon's mass grew, the blows it received were progressively harder, and for a time their frequency also increased. The rate of heating probably reached and passed its maximum while the mass was materially less than now. During the whole period of growth the surface lost heat by radiation, but the process of growth cannot have been slow enough to permit the concurrent dissipation of all the impact heat. On the one hand, there should have been some storage of heat in the interior, and, on the other hand, the stored heat can never have sufficed for the liquefaction of the nucleus. Toward the close of the process, when blows were hard but rare, liquefaction was a local and temporary surface phenomenon, but the general temperature of the surface was low. Impact heat, being evolved simultaneously in the surface and the subsurface, was dissipated more rapidly from the surface, so that there was a subsurface zone of relatively high temperature.

The zone thus inferred deductively is also inferred inductively from the disparity of cavities and rims in the case of large craters; but, on the other hand, there is little evidence of the wrinkling which, theoretically, should result from the adjustment of a cold crust to a cooling nucleus. * * * It is therefore probable that the final shrinkage of nucleus was small, and the antecedent storage of heat correspondingly small. During the whole period of growth the body of the moon was cold.

After thus stating the hypothesis of Gilbert for the origin of the moon, in his own words, it is not needful to consider here in detail the numerous arguments which favor vulcanism, instead of impacts, as the cause of the moon's craters. The adoption of Gilbert's explanation of the physiography and development of the moon would go very far toward conclusive verification of the planetesimal hypothesis; but Chamberlin evidently thinks that volcanic origin of the lunar craters is more probable.

Gilbert considers the whole process of the moon's gathering its formerly scattered material to have been completed at least before the deposition of the earth's Paleozoic sediments, else they would here and there reveal evidences of collision of some of the portions of the previous ring matter, since these must have fallen not only on the moon but in like manner on the earth. Whether the craters of the moon resulted from meteoric aggregation or from vulcanism, the very steep and high mountains of the crater rims have doubtless remained through very long ages unaffected by agencies of erosion, because of the absence of atmosphere.

Geologic antiquity, as hitherto studied, falls far short of reaching back to the time of completion of the creation of these companion globes, the earth and its satellite, in nearly the same size and condition which they have now. But in the new views opened by the hypothesis noticed in this paper the range of geologic inquiries and theories is extended almost inconceivably farther back, through the laying of "the foundation of the earth."

DR. NANSEN'S "BATHYMETRICAL FEATURES OF THE NORTH POLAR SEA, WITH A DISCUSSION OF THE CONTINENTAL SHELVES AND THE PREVIOUS OSCILLATIONS OF THE SHORE-LINE."*

A Review by J. W SPENCER.

This is one of the comprehensive scientific memoirs which have been the outcome of Dr. Nansen's Arctic explorations. While it treats of the physiographic features of the Polar basin, yet the greater part is devoted to the investigation of continental shelves, not merely of the Arctic basin, but also those of the Atlantic, in which respect it is the most important work that has appeared anywhere, and along with that is the investigation of the drowned valleys dissecting the shelves.

Dr. Nansen has considerately, for us English-speaking people, written in our own tongue, but as his monograph is published in Norway, few in this country will be able to see the original work, and yet the book is absolutely necessary for any serious student of the subject, but for those who cannot see the original an attempt at summarizing it may be of some assistance.

Dr. Nansen tells us that he planned his expedition, on the assumption that there was a free Polar sea, and expected along with most geographers that it was comparatively shallow. But the discovery of the great continental slope in front of the broad submerged shelf of the Eurasian continent, reaching to a depth of 4,000 metres and more, proved the existence of a great sea basin, only limited by the rise of a corresponding slope to the continental shelf of the American side. How far the shelf extends beyond the American archipelago is not known, but certain it is that there is deep water at the North pole. This feature is illustrated in a finely executed colored chart, giving us a graphic idea of the size and form of the true basin.

North of the low Siberian coast, the continental shelf reaches to 640 kilometres in breadth, at which point its depth below the sea is only 156 metres. The width of the shelf from Alaska, north of Bering strait and Siberia to Franz Joseph land, is nearly uniform, though in places re-

* Quarto, pp. 232, plates 28. Published by the Fridtjof Nansen fund for the Advancement of Science, Christiania, 1904.

duced by projections from the coast; with a general depth of less than 100 metres. In the vicinity of Bering strait, Nansen gives three sections of the continental shelf, two of which after showing a breadth of nearly 400 miles begin to descend abruptly as if their border were approached. Even the fragmentary evidence on the American side indicated that the edge of the shelf (reduced to a width of 70 kilomtres) is at the same depth of about 100 metres as elsewhere. Franz Josepf land and Spitzbergen are located on the outer edge of the shelf which is here somewhat broader. The depth is irregular, showing that the platform is dissected by valleys communicating with the Polar basin at one end, and the Norwegian sea at the other. This is on the floor of Barentz sea, which extends from these islands to Novaya Zemlia and the Norwegian coast. The irregularity of the soundings in this sea may in part be attributed to the partial filling of the ancient valleys by glacial deposits, river silts, the drifted sediments of coast-wise wash and the levelling effect of the floating ice on the bottom of the shallow sea, but the valleys themselves are more or less apparent. These are described in considerable detail, along with their tributary branches, as well as those of Kara sea. The valley-like features are traced to the edge of the submarine plain, but the soundings in them have not generally reached to more than 400-500 metres. (Still the reviewer had observed a cove to 8,100 feet incising the continental slope southwest of Spitzbergen, where the depth below the sea level is only 840 feet. This indicates that the valleys extend to the floor of the basin.) The rapid descent from the shelf is shown in various places. Some idea of this last feature may be obtained north of Spitzbergen, where in a distance of about 30 miles, a slope from 171 metres to 1,150 occurs. In his great discovery of the deep Arctic basin, Nansen found the slope north of the New Siberian islands reached from 100 metres on the edge of the shelf to over 1,920 in a distance of 40 miles.

Off the Siberian coast, he did not find the valleys on the surface of the shelf, which fact he attributes to their refilling by the coast-wise distribution of the sediments brought down by the great rivers. But he observed many

typical valleys in Kara sea, and these may have been left open on account of their great distance from the Siberian or other rivers. The soundings in Barentz and Kara seas are "sufficient to show that the physical features of the bottom bear a striking resemblance to a former sub-aerial region" as there is an "extensive coherent system of broad submarine valleys * * * with many tributaries draining an extensive area of the ancient continent as far east as Novaya Zemlia. * * * The whole bottom seems to have been elevated above sea level * * * at some previous and probably not very remote geological period * * * No other theory would in my opinion serve to explain the origin and presence of such a system of valleys under the water of the sea. * * * Valleys may be formed by faults or folding * * *. But we cannot expect the depressions thus formed to assume, without the aid of meteoric agencies the shape of typical river valleys with numerous branches or tributaries or converging into a trunk valley, which on the whole gradually deepens towards its embouchure opening out into the oceanic abyss." (p. 26.) He further points out that if the ridges between the valleys in this region have been formed by seismic movements they must have been dissected by erosion of some kind, for all the transverse valleys could not have been formed by tectonic strains, as they exhibit typical features of river-formed channels, afterwards occupied by glaciers. These features on the shelf required an elevation of 450 metres above sea level and probable much more, and he regrets our lack of information which prevents our defining the amount. He also shows that the channels, as that at Värdö, have not been excavated by submarine glacial erosion. These valleys were formed at a time just preceding the Glacial epoch. Then they were occupied by glaciers, which deposited detritus in the valleys, as they were receding during the subsequent subsidence of an inter-Glacial epoch, which culminated when the sea had reached 100 metres above the present level. Then recurred another elevation, followed by the latest Glacial epoch. The valleys were partially re-excavated, and according to Ramsay the glaciers did not reach the coast. A second submerg-

ence to about 70 metres below the present followed. A third elevation raised portions of the sea bottom so that the glacial deposits were incised by new channels, now forming some of the submerged valleys. Again a third depression brought the land down to 21-22 metres, after which it rose to the present hight. (pp. 34-35). Nansen finds a remarkable repetition of changes which the reviewer has shown as occurring on this side of the Atlantic.

In the American archipelago, Nansen calls attention to depths of 411,512 and more than 732 metres, as well as shallower ones, indicating that the region is one of typical fjords with channels opening into the Polar basin, though they may be found obstructed as in the case of the Norwegian fjords; and he further considers that the Arctic basin is not very distant.

Even without soundings on the American shelf to show its limit, Nansen says "the Fram cannot have drifted along a deep and narrow sub-ocean channel." He especially mentions that the existence of the cold bottom water makes it "perfectly impossible." The heavy bottom water at more than 800-900 metres, originating from the inflowing Atlantic, cannot have been cooled down at the observed depths, beneath the overlying warmer water, and the lower layers, affected by subterranean heat; it must have cooled down somewhere in the unknown portion of the Polar basin, in contact with the surface layer of cold water—this at some place far off from the course of the Fram. Similar conditions exist in the Norwegian sea, where, however, the centre of cold surface water has been found north of Jan Mayen. In the Polar basin, Nansen locates the centre of cold surface water somewhere between the North Pole and Bering strait; but the bottom water is not reduced to quite so low a temperature as in the Norwegian sea. Accordingly "we are obliged to assume that it (the deep basin) has a wide extension," probably the greater part of the still unknown Polar region (p. 228). Finally the drift of the ice, under the east coast of Greenland, is much greater than farther north, where the ice belt must correspond to the broader one in the known and unknown Polar sea, from which it converges.

There are two distinct layers on the bottom of the Polar seas;—a brown clay resting on gray clay, or vice versa—the brown requiring the longer time for its accumulation. This difference may in part have arisen from more waste being carried down to the sea at one time than at another; or with equal probability, it may be due to the movement of the shore lines, causing the advancement or recession of the mouth of the river, but only a considerable change of level of land and sea would make a difference where the oscillating coast line was characterized by a steep descent.

The Siberian continental shelf, northwest of Koteloi, at 1,400 metres, showed 10-11 centimetres of gray clay resting on the brown, as a distinct layer, with no Foraminifera in the gray, and only rarely in the brown. The composition of the two kinds is nearly the same. The brown color indicates a slower rate of deposition. The comparatively recent submergence of the Siberian tundra (100-150 metres) would greatly reduce the basins of the rivers, causing the embouchures to recede so that the sedimentation down the continental slope would permit the slow accumulation of the brown deposits. The rise of the land would favor the deposition of the gray. In Barentz sea, a very thin upper layer of green clay rests on the gray.

In the basin of the Norwegian sea, which is separated from that of the Arctic, by a ridge between Spitzbergen and Greenland, the brown oxidized clay rests upon the gray, which contains no animal remains, or any great amount of carbonate of lime. On the continental slope, to about 900 metres, the layer of brown clay is very thin, but it increases in thickness on approaching the oceanic depths. So also the ***Biloculina***, etc. increase as well as the percentage of carbonate of lime to 15-20 per cent in the true foraminiferal clay. The gray clay must have here been deposited in a former period, when there was a rapid deposition of terrigenous waste with very little animal matter. This can be explained by the Norwegian shore line extending seaward, when the land, compared with the sea-level stood much higher than now. At such a time the Greenland-Iceland-Scotland ridge cut off the Atlantic

waters, thus affecting the warm currents and the distribution of life.

A conspicuous feature of the Polar basin is the small amount of Foraminifera and of carbonate of lime, in one case five per cent, in others from one to three per cent. This scarcity may be attributed to the absorption of light by the ice. The deep sea brown clay, which prevails on the bottom of the Polar basin, is very much like the Biloculina clay which occurs in the Norwegian sea (this organism does not occur here), but the percentage of lime is very much less. These organic deposits indicate former more favorable biological conditions. Very little terrigenous matter reaches the deep basin from the rivers, and the fineness of the deposits there compared with the coarse material of the coast region, shows that there has been no great glacial drift across the Polar basin. Nansen very rarely found any stones, as large as a pea, on the floe-ice, but in many cases, dust and mud were seen in quantities. In a very cold sea even the shore ice travels across it without depositing its load, and in this case it finally melts east of Greenland, where the débris sinks to the sea floor.

The continental shelf of Barentz sea becomes contracted to about 50 kilometres off the Norwegian coast in front of the neighboring high mountains from Tromsö to Vesteraalen, but beyond it widens out, supporting the Lofoden islands, and reaches the breadth of 250 kilometres in the vicinity of latitude 66°. The edge of the shelf then turns landward so that it recedes to within 80 kilometres of the coast in front of Aalesund. Farther on, it turns westward, and the continental shelf itself is represented by the floor of the North sea, near latitude 62°. This definition requires further explanation, for from this point southward and around to Christiania fjord is the merest fringe of the continental shelf, which might be said to disappear, if it were not repeated on the other side of the broad submarine Norwegian channel, as the floor of the North sea; accordingly the great shelf itself is only incised by the channel, which is a minor feature. This Norwegian channel extends inward for 480 nautical miles, with a breadth of 40-56 miles, to Christiania fjord, having the Sogne fjord

and other tributaries. It is so close to the shore that the higher portion of the continental shelf does not appear. This channel ends abruptly in three tributary fjords.

The soundings of the continental shelf display many irregularities, on account of the incisions in it. The great valley fjords cross it. These are obstructed by barriers near the outer coast line. The shelf is naturally best developed between the valleys, and the broadest and deepest shelves or platforms are situated in front of the lowest coast, and the highest and narrowest in front of precipitous coasts. The author distinguishes a coast platform from the general shelf. This is where the shallow sea is studded with low islands and skerries. It has an important bearing on the question of the origin of the shelves considered later. The local descriptions with sections are given in great detail, and these are necessary to understand the general characteristics.

The Norwegian shelf, almost everywhere, terminates abruptly, and its very level or gently undulating surface is in contrast with the rapid descent of the continental slope extending to oceanic depths. On this the gradients are steepest between 200 and 1,000 metres, becoming gentler from 1,500 to 2,000 metres. Even down the slope, evidences of river-like valleys may be traced to the greatest depths where soundings have been made. North of Andö they have thus been found to over 1,000 mteres, within the edge of the shelf itself, which here has a depth from less than 100 metres to 400 according as it is the upper or lower platform. Many undulations in the isobaths of the slope indicate channels to 800 metres.

From Barentz sea to latitude 67° the upper levels of the continental shelf usually reach to its very edge; as also beyond latitude 64°. Between these points, the main shelf is indented by an embayment, which is floored by a lower plain, whose outer edge is bounded by the 400-metre line. This lower submarine plateau reappears in the Norwegian channel, and far north in Barentz sea.

Sometimes the valleys appearing on the continental slope lie outside of the line of the modern channels. This is attributed to a diversion from the older ones apparent

at the greater depths, owing to glacial or other deposits filling the original channels.

The submarine fjords crossing the continental shelf characteristically reach to a depth of 400-500 metres, and in the north, the land-bounded fjords inside have a similar but only slightly greater depth, while in the south, the inner ones are much deeper. Between the inner and outer fjords, the channels are often shallowed to within 300 metres of the surface of the sea. This 400-500 metre base level is repeated on the ridge between Scotland and Norway and in Baffin bay.

In central Norway, there is a tendency of the fjords to follow a combination of longitudinal and transverse valleys. This is regarded as proof that the surface features of the country are due to water erosion and not to glacial, according to Prof. J. H. L. Vogt. The conclusion that the longitudinal ones are due to the erosion of rivers is also supported by Dr. H. Reush and Prof. W. C. Brögger. While the denuding agents may have obliterated the last traces of the folds, Nansen thinks that such tectonic causes brought to the surface the layers of the more yielding rocks upon which the agents have acted. With this additional expression, the author agrees with Vogt that the broad longitudinal and the narrow transverse valleys owe their origin to running water and not to glaciers for "a great ice sheet has necessarily a much greater tendency than running water to carve valleys along directions radiating from the central region or axis of the land," etc. (p. 57). Even the Norwegian channel, though perhaps primarily determined by structure was fashioned by running water and not by glaciers, which were "hardly sufficiently dependent on the tectonic structure of the underlying ground to form parallel valleys" to those of the plateau (p. 62). Along with previous writers Nansen considers the Norwegian channel as the continuation of the Baltic river draining that basin, which originated by tectonic dislocations, in some remote period, but whose present outline is due to atmospheric erosion (first river, then glacial) and subsequent partial filling with drift (p. 63). The breadth of the channel does not interfere with the theory endorsed.

The Sognefjord and others are not here discussed, but the barriers are analysed in a masterly way, so as to leave no other conclusion but that they are the result of glacial filling with coast-wise drift, thus agreeing with Hull and others. So strong a case does he make out that those who would have them rock basins must assume the burden of the proof of such a proposition.

On the floor of the North sea Nansen finds five distinct terraces; namely, at 30-50, 66-80, 115-130, 155-217, and 384-439 metres.

Leaving Norway for Faeroe and Iceland,* which are on the incised ridge extending from Scotland to Norway (Wyville-Thomson), Nansen finds remains of the continental shelves from 40 to 100 kilometres broad, with the precipitous coast descending abruptly to 50-80 metres below sea level to the shelves, the greater portions of which lie between 100 and 170 metres. Consequently there is an absence of the coast platform and its skerries. The many fjords incising the shelf are less barred than in Normay and are known to a depth of 350 metres, where information ceases. A sub-oceanic terrace at 1105-1175 occurs north of Faeroe, and one at 1177-1215 to the westward and between here and Rockall bank at 1134-1189. (p. 73). On what corresponds to the continental slope, even the limited soundings show submarine channels to more than 500 metres. One southeast of Iceland, almost with a canyon shape, reaches to 1174-1246 metres, forming an incision in the floor to at least 600 metres, and probably to 800-1,000. A little beyond appears a platform at 640 metres. The apparently submarine base level so often found near Norway at 400-500 metres is repeated here. Indeed, the Scotland-Greenland ridge, with its shelf and lower base level, decidedly resembles a mountainous plateau, denuded by atmospheric agents. The submarine peneplain, bounded by the 500-isobath, extends with two narrow interruptions all the way between the two continents and separates the Norwegian sea from the Atlantic basin. It is however incised by a channel between Scotland and Faeroe reaching to 1015-1088 metres below the surface of the sea. It opens south-

* Also briefly studied by the reviewer and others whom Dr. Nansen always credits in full.

ward to a suboceanic plain submerged to 1042-1326 metres. From the col of this (Lightning) channel another valley extends northward to the basin of the Norwegian sea, suggesting a lower base level at 1262 metres. Between Faeroe and Iceland is the plateau at 400-500 metres. Between Iceland and Greenland the ridge and plateau is not quite so deep, but it is cut by a channel of 958 metres rapidly descending towards the north to 1560 metres far within the edge of the Greenland-Iceland continental shelf. (p. 84.)

Off the west coast of Greenland, the remains of a continental shelf dissected by fjords is a pronounced feature of which a less complete study has been made in America.* The coast platform with its skerries are here repeated, but with inferior development to that in Norway.

The continental shelves and submarine valleys of Europe and America are reviewed with full credit to the previous workers on the subject. In fact, the agreement between those of us† who have done any considerable work on the subject, and therefore entitled to some opinion, seems to be complete in all essentials; but along with his own researches Nansen has brought the whole subject together, into a treatise which must be epoch-making.

The "coast platform" of Dr. Nansen, which is that portion of the shelf bearing the skerries or low islands, has been principally formed by marine denudation, vigorously assisted by atmospheric erosion, as subsidence was not always necessary, for there were various episodes of oscillations of land and sea. This coast platform has been cut subsequently to the excavation of the fjords. In this respect Nansen disagrees entirely with Reusch, Davis and Vogt. He sees no reason for accepting their theory, and says: "On the contrary, I consider it impossible that a broad and very gently sloping coast platform can be formed on a high coast which is not deeply dissected by fjords. If in general a broad plain of marine denudation actually be formed on smooth, undissected coasts, which are slowly submerged, as assumed by Richthoven, its slope

*By the reviewer.

† By far the most extensive contributions have been made by Prof. Edward Hull and by the reviewer, some of which only have been referred to.

must at any rate, become much steeper than that of the coast platform." Under such conditions, 'the force of the waves would be broken long before they reached the shore. There would be little opportunity for the waste formed by marine denudation, as well as the waste carried by rivers, to be washed away into the deeper waters" except by tidal and wind currents, (p. 105) which would heap up beaches that would further protect the cliffs from marine erosion. In the case of fjord-dissected coasts, the marine denudation would be facilitated by the deposition of the waste in the deeper channels, so that the unbroken waves could reach the cliffs. However the last glaciers may have swept away previous accumulations of waste, thus re-opening the channels. So also atmosphere erosion is more effective on a deeply dissected coast than on a smooth one. The coast platform would be found in shallow water after the submergence of the channeled peneplain.

While continental shelves resemble coast platforms, they are more complicated and of greater extent; as for instance extending from the Arctic basin to Patagonia, with their depth ranging mostly between 50 and 200 metres.

The four chief methods of production seem to be: that they are submerged coast platforms; submerged peneplains; constructed by sea deposits; and built up by glacial drift. Dr. Nansen concludes that the continental shelves of the world have been formed partly by coastal deposition of terrigenous waste, and partly by the conjoint action of sub-aerial erosion (i. e. submerged peneplains) and marine denudation; and in seas favorable coral growths have been important. In regions of rapid coastal sedimentation, this method of formation has been primary; but it is not certain that favorable conditions obtained wherever broad banks occur, as those off Newfoundland and the shelf of the English channel. In such cases erosion has predominated in the formation. The Norwegian and Iceland shelves have been cut in solid rock at sea levels lower than now. "It can hardly be merely an accidental coincidence that the shelves have nevertheless levels which are nearly identical with those of other continental shelves," of similar

origin. The shelves partly cut by erosion and partly built up by waste may be compared with raised cut-ledges and raised beaches and terraces built up by waste. (v. p. 193). The combined sub-aerial and marine denudation have had the greatest effects during periods of oscillations of the shore lines. During elevation the streams would incise the coastal plains, and these dissected would furnish the most favorable conditions for marine erosion. By such repetition broad shelves would be formed, and most coasts have probably undergone many oscillations. "The effect of marine denudation can never become great on smooth undissected coasts; dissected coasts will be cut back till they become smooth." The continental shelves of the world have been subjected to changes of level simultaneously with and after, their formation; they have only to a very small extent been formed after the time when the present shore line was attained (p. 194).

The shelves of Iceland and the Faeroe islands have been built up in Pliocene and Pleistocene times, and Nansen believes "that the continental shelves of other regions are to a great extent of similar age" (p. 186). He concludes with Hull, that those of the Scotch islands belong to a similar date, and he cites the present reviewer as showing that the age of the valleys dissecting the American continental shelf corresponds to that of Europe (p. 187). The canyons and channels must have been made subsequently to the shelves. For example, he says that Fosse de Cap Breton" is perfectly incompatible with the assumption that the shelf was formed after the last submergence of the drowned valleys, if we assume that this remarkable ravine is an ancient river canyon, other than which I (he) think there is no feasible explanation" (p. 190), thus strongly supporting Hull and others in this and other canyons off the coast of France. He sees no evidence against the existence of the submarine valleys and their being filled with drift and leveled over with wave washes during oscillations.

"We see that it is difficult to find conclusive evidence that the continental shelf * * * has been elevated into dry land after formation; but the drowned valleys and fjords at many

places make this highly probable and at some places—e. g. the Fosse de Cap Breton, the Congo submarine canyon, the Bottomless pit—there seems no other feasible explanation to be found. Some drowned valleys on the American side of the Atlantic seem perhaps to give still better evidence of such a recent elevation. Even if we admit that the long submerged channel of the St. Lawrence river might possibly, although not probably, have been reopened by submarine glacial erosion, * * * it seems also highly improbable that the drowned valleys of the Newfoundland bank, far from land have been reopened by submarine glacial erosion. The drowned valley of the Hudson river cannot possibly have been reopened by submarine glacial erosion. It is too long, and narrow, and too deep. Its narrow and well defined channel, cut in the extremely level continental shelf, seems to prove that the latter has comparatively recently been elevated into dry land. Prof. J. W. Spencer has described a great many drowned valleys along the coasts of the West Indies and the United States south of the drowned Hudson valley. Although Spencer's description of the drowned valleys may often be based on too few and scattered soundings, to be absolutely certain, there are a good many submarine features in this region which cannot easily be otherwise explained, and which indicate vertical oscillations of great amplitude, of the shore line, as Prof. Spencer has pointed out in such an ingenious way. According to his investigations the drowned valleys of the continental shelf, as well as the valleys of the coast, have been filled and reopened several times according as the shelf was submerged or elevated into dry land. * * * The shelf cannot have been covered by much deposit after the last submergence. * * * Thus * * * there is weighty evidence that the drowned valleys have been sculptured after the formation of the continental shelves, and that consequently the latter have been dry land after formation, * * * if at some places * * * also at least in neighboring regions; for considering that the continental shelves have retained practically the same level mutually, the oscillations of level cannot have been due to quite local tectonic movements." (pp. 191-192.)

Of the stability and oscillations of the shore line, Dr. Nansen says that the well developed continental shelves of the earth prove that the general level of the hydrosphere must have remained near its present position during long recent geological periods. This is illustrated by Sir John Murray showing that 40 per cent of the continental area is situated between 200 metres above and below the present sea level. But the sea level has not remained stationary, as it has been conclusively proved to have oscillated be-

tween the outer edge of the continental shelf and the inner boundary of the low lands. The marine sediments on the coastal plains prove them to have been covered by the sea. The eroded parts of the continental shelves could not have been developed at the present sea level. The "submerged dissected coasts in nearly all regions of the world indicate also a universal comparatively modern transgression of the ocean, for it seems highly improbable that nearly all the coasts could have been simultaneously depressed by tectonic movements." The coral reefs indicate a universally late rise of sea level, while the elevated reefs indicate a pause in the vertical movements. The drowned valleys and fjords of the continental shelves and sub-oceanic continental slopes, * * * as of Norway, Fosse Cap Breton, Congo, St. Lawrence, Hudson, etc., prove that there have been much greater oscillations of shore line; and this is confirmed by the suboceanic platforms and terraces, as the Blake plateau, one southwest of Faeroes (at 1200-1300 metres below the surface (p. 197), and deeper ones may be added by the reviewer.

"What are the possible causes of these oscillations of the shore line? Are they due to movements of the lithosphere or to possible oscillations of the hydrosphere or perhaps to both?" According to J. W. Spencer's interesting investigations of the drowned valleys of the Antillean region there have been a great many oscillations of the shore line during late geological periods. He believes that these oscillations have been due to epeirogenic movements, and assumes that in neighboring regions (it should be pretty distant one) "they have frequently not been simultaneous." He further says that this does not harmonize with the remarkable uniformity of levels of the shelves. (p. 198). "The greater part of the shelf must, according to Spencer's own description have been formed (as a coastal plain) prior to the formation or at least prior to the reopening of the drowned valleys." Nansen thinks it "impossible that the vertical oscillations of the shore line can have been due to more or less local tectonic movements, a fact which has hitherto hardly been sufficiently appreciated." The reviewer wishes here to state that at the

time when he made the studies just referred to by Nansen, he was the pioneer in searching into these deep drowned valleys, without the suggestive assistance of Prof. Hull and Dr. Nansen, and the whole problem was too great for one worker. So when he comes to revise his earlier studies, they will have the great advantage of the new light now thrown on the question, and doubtless there will be close agreement in our views, when dealing with the same phenomena, for in such discordance as referred to he thinks "that there may be other explanations, and he does not consider it necessary to assume that the continental shelf has undergone the same changes of level along its whole length—even though at some places it may have been elevated more than 1,000 metres and again lowered to its original position" (p. 199). The "facts indicate that on one hand there has been during very long periods a certain stability of sea level," but at the same time "great oscillations above and below sea level * * * have occurred at different periods." Also "a late and more universal rise of sea level of perhaps 100 metres or more accompanied by perhaps several oscillations of the same kind." A crust floating on the underlying magma he compares with an unequally loaded ice-floe subjected to changing "ice-pressures." The thermal contraction and expansion of the rocks, are discussed at some length as to their bearing on the changes of level, and it is perhaps the most suggestive consideration, although the transposition of the land-waste to the sea, accumulation of glaciers and their melting, etc., are considered. There seems no satisfactory explanation of the cause of the great changes of level of the land and sea, but after each disturbance there is a tendency to return to equilibrium, "probably determined by the buoyancy of the crust floating on a liquid magma" (p. 213). "A theory which would explain the above facts must recognize the tendency, whether the disturbances be due to the lithosphere or hydrosphere" (p. 200).

PROF. SHIMEK'S CRITICISM OF THE AQUEOUS ORIGIN OF LOESS.

By G. FREDERICK WRIGHT, Oberlin, Ohio.

In criticising the papers of Miss Owen and myself in the American Geologist for April, 1904, defending the aqueous origin of the loess in the Missouri valley, Prof. Shimek makes several statements which are likely to be misleading, unless our own position is more clearly stated. At the outset it should be said in general that we are not maintaining the entire absence of eolian agency in distributing the loess. We may be allowed to appeal to the agency of wind to account for various abnormal deposits which could not be accounted for on the aqueous theory. Our only contention is, that the main deposits bear unmistakable evidence of water deposition.

The most important points in our statement of the case which Prof. Shimek challenges are:

1. "That the bluffs of loess on the west side of the Missouri river are scarcely, if any, less than those upon the east side." This statement Prof. Shimek challenges, affirming that, "as a rule, they are higher, more abrupt, and with thicker loess deposits on the east side, and the same is true of the Mississippi." Probably Prof. Shimek is correct in this. I spoke only from a general impression, which is certainly correct, that the loess bluffs upon the west side of the Missouri river at Omaha, Plattsmouth, Nebraska City, Leavenworth, and Kansas City are very extensive, and that is sufficient for my argument in the case. The prevailing winds in that region are westerly in the ratio of about three to one. If this loess had been blown up from the flood-plain of the Missouri by winds, the deposits upon the east side should be three times those upon the west, which no one would contend is the case.

Prof. Shimek resorts to local "topographic features," "meanderings in the river valley," and "inequalities in forest and plant distribution during the deposition of the loess," to account for the instances where the depositions on the west side are greater than those on the east. But such local conditions can be much more readily appealed to in explanation of the larger accumulations upon the eastern side.

It should be observed that the principal loess accumulations are clearly connected with the closing stages of the Iowan glacial epoch. The loess-covered area of southern Iowa begins very abruptly south of the terminal moraine of the Iowan epoch. While that area is completely enveloped in loess, it is almost entirely absent over the area of the northern part of the State which was covered with Iowan ice. This points with unerring accuracy to the floods of the closing stages of this period as the principal source of the material thus deposited. A little study of the map will show that during those floods a large number of tributaries coming into the Missouri river upon its eastern side would contribute an abnormal amount of material to that side of the river. There are half a dozen such streams coming into this area above Council Bluffs, while, below, the Nishnabotany, the Tarkio, the Nodaway drain a large basin in southern Iowa, coming into the Missouri a short way above St. Joseph, where the loess accumulations are more pronounced than anywhere else, while the Platte river, draining a still larger area in southern Iowa though reaching the Missouri in the vicinity of Kansas City, passes within five miles of St. Joseph, and is there connected with the Missouri by a low pass, which would be submerged in the more moderate of the glacial floods. The influence of these contributors of sediment of the Iowan glacier will fully account for the excess of loess upon the east side of the river and for its special occurrence along the valleys of these streams themselves. Many other streams similarly related to the Iowan field cross the loess-covered area farther eastward towards the Mississippi river.

2. Prof. Shimek represents my description of extensive level-topped terraces in the loess-covered area as conveying "an exaggerated idea of the extent and frequency of such terraces." In reply it is only necessary to say that the argument is not dependent altogether upon the extent and frequency of such terraces. More special attention to one instance adduced will be sufficient here.

The fort at Leavenworth is situated upon a partially dissected terrace on the west side of the Missouri river, whose general level is about 150 feet above the river. This

general level, which has all the appearance of a terrace, is covered with loess, and extends, upon an average, for about a mile back from the river, where it is bordered by an abrupt ridge, rising about 200 feet higher. The terrace continues southward through Leavenworth, and is distinguishable at Lansing, a distance of several miles, while on the other side of the ridge from the fort the same level continues for an indefinite distance northward. An examination of this one instance is sufficient to convince the observer that wind alone would be inadequate to produce the results. It is just such a result as is continually being produced by flooded streams. Other instances can be adduced almost without number. Such a well-defined terrace as this exists within the limits of Omaha itself at a hight of 100 to 150 feet.

3. The question concerning the prevalence of land snails in the loess and the absence of distinct water species is answered by observations recently made by Miss Owen on the fossils of the loess at St. Joseph soon to be published. If I am not mistaken distinct water species are not often found upon the flood-plains of streams, where the water remains for only a short time.

4. In "stripping of its verbiage" my account of the glacial boulders found at Tuscumbia, sixty miles above the mouth of the Osage river, Prof. Shimek has stripped it of its principal significance. He adduces the case of a small boulder found at Eureka, Kan., 75 miles southwest of the extreme limit of glaciation in the valley of the Arkansas river as comparable in significance to the clusters of boulders weighing several tons which were found in the trough of the Osage river. But there is really no comparison between the facts. The Eureka pebble may in some way have come down the Arkansas valley from the Rocky mountains, or it may have been carried some distance by the hands of man, for it only weighed 360 pounds. But the Osage river boulders (one of which would weigh three or four tons) tell a very different story, as any one who reads my description, giving due weight to the "verbiage," may easily see.

5. In connection with the same criticism and one

which follows relating to the inadequacy of the floods I had supposed to account for the highest deposits of loess it is important to call renewed attention to a point explicitly made, that the supposed adequateness of the flood to account for the phenomena was dependent upon the supposition of a differential depression of the land to the north. This is necessary to secure the gradient supposed for the production of the slow rate of the current which passed through the narrow place of the Missouri trough. This differential depression towards the north is in analogy with all the positive facts that are known upon the subject, and is therefore lawfully made, and it provides that balancing of forces which we need to account for all the phenomena. The current was slow, not over three miles an hour. Such a current was not sufficient to lift sand up to the higher levels of overflow, where lakelike conditions existed on either side of the central flow of water. This accounts for the fineness of all that upland deposit, and indeed for the deposit itself. On Prof. Shimek's theory the rapid current of his flood would have carried the loess all down the river, and left nothing for the wind to get at. The sandbars of the Missouri are not covered with loess after floods.

6. Since publishing my last paper, I have extended my observations down the Mississippi river on both sides to as far as Vicksburg; and, while not ready at present, fully to publish my conclusions, I may say that it seems to me we shall be compelled to suppose that the epeirogenic downward movement affected to a considerable extent the whole valley of the Mississippi, this being necessary to account for the deep loess deposits covering Crowley's Ridge on the west side, and marking the border of the Yazoo delta, often fifty or sixty miles east of the Mississippi river, extending from Memphis to Vicksburg. In floods at the present time the Mississippi spreads over this delta, forming a slowly moving temporary lake seventy miles wide. With larger floods and more abundant supply of loess, the Mississippi would be now rapidly building up a loess terrace over that region in which there would be no intermixture of sand, and over which the water would not remain long enough to support the distinctively water species.

of mollusks. Moreover, there would be ample time for the annual growth of vegetation which would prevent the wind from seriously modifying the deposit. The analogy between such conditions and those which must have prevailed in the vicinity of Carrollton, situated on the margin of the loess east of the Yazoo delta, was very striking and suggestive.

CHEMISTRY OF CALIFORNIA PETROLEUM.*

PAUL W. PRUTZMAN.

The chemistry of the petroleums produced in California is involved in considerable obscurity. Investigations of this character are so difficult and tedious, and the rewards so doubtful, in a practical way, that very little research along these lines has been attempted, and it is probable that no single sample of Pacific coast petroleum has ever been resolved into its proximate constituents. But though detailed information is lacking, some facts of a general nature may be brought forward, and these points, scattering as they may be, will yet throw some light on the ultimate nature of the oils with which we have to deal.

Hydrocarbons.—It is very evident, from a good many considerations, that the hydrocarbons making up the body of California petroleum are radically different from those of the oils of the eastern states. The low flash point and boiling point in relation to the specific gravity, the practical or entire absence of solid paraffins, the presence of asphalt in most of our oils, and its ready formation on heating oils from which it has been removed, or in which it was originally absent, the rapid fall in viscosity of the heavier oils with rising temperature, and the strong tendency of most of our oils to oxidation, all point to the probability that the composition of our oil is quite distinct from that of Eastern petroleum.

The petroleum of the eastern states is known to consist almost entirely of paraffins in the lighter members, and of

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* From Bulletin No. 32, of the California State Mining Bureau, March 1904.

paraffins and olefins in the heavier portions. The petroleums of the Caucasus are stated to consist principally of the naphthene group, while some German petroleums are stated to contain notable proportions of hydrocarbons of the benzine series. Various observers† have found in California petroleum all of these constituents, and as a discussion of this very abstract question would be out of place here, reference is given to the original papers for justification of the statement that most California petroleums, or rather their distillation products, contain hydrocarbons of all the following series: paraffins, olefins, probably acetylenes and other highly unsaturated compounds, naphthenes (cycloparaffins), and aromatic (benzene) compounds.

A very few of the local oils give a light distillate which appears, from its specific gravity and other physical properties, to consist largely of paraffins, but the major part of our oils give a light distillate which is much heavier than a mixture of paraffins of corresponding boiling point could be. By acting on these gasolines and kerosenes, the olefins may be removed, and as sulphuric acid used in excess absorbs but a very small proportion, it may be assumed that the olefins are not present in large quantity. After rigorous treatment with sulphuric acid, a varying but large proportion of the oil is acted on by nitric acid, forming a stable nitro-compound, and leaving a residue which can not be further affected. This residue is very much lighter than the original oil, and from its resistance to all reagents probably consists of pure paraffins. The portion removed by nitric acid may be either benzenes or naphthenes, or both. It is probable that the latter is the case, though the percentage of benzenes must usually be quite small, as the gravity of benzene proper (C^6H^6) is about 28° Be., and the boiling point 80°, while the gravity of local petroleum, distillate boiling at this temperature is well above 70° Be.

†Consult—
A. S. Cooper. Mining and Scientific Press, 82-123; Bulletin 16, State Mining Bureau.
Felix Lengfeld and Edmund O'Neill. Amer. Chem. Jour., 15-19.
Charles F. Mabery. Am. Chem. Jour., 19-796; Am. Chem. Jour., 25-253; Jour. Soc. Chem. Ind., 19-502.
S. F. Peckham. Am. Jour. Science., 3-48-250; Science, 23-74.
Clinton Richardson. Jour. Soc. Chem. Ind., 19-123.
Frederick Salathe. 13th Report of the State Mineralogist.

der of the crown including the greater part of the protoloph is very much damaged.

The crown of the molar obtained last summer is practically perfect and has been subjected to little wear during the life of the animal. It is probably the second molar and is shown in the accompanying figures. This tooth is brachyodont, with well-developed low cross crests (protoloph and metaloph). The crown, seen from below, is suboblong in outline, transversely broader in front than behind, and relatively narrow in an antero--posterior direction. The outer border (ectoloph) rises higher than the cross crests. The latter are unequal in length, the protoloph being longer, and better developed, than the metaloph. The intermediate cusps (protoconule and metaconule) are both well-defined although the protoconule is larger than the metaconule and more distinctly separated from the protocone than is the metaconule from the hypocone. The protocone is slightly larger at its base than the hypocone, but both have about the same hight. There is no hypostyle. The parastyle is large and adds considerably to the crown's anterior transverse diameter. The mesostyle and metastyle are distinct, and the ribs are distinguishable, the anterior one being the better defined of the two. The cingulum is well-developed and passes from the metastyle entirely round the inner side of the crown to the parastyle without interruption except for a short distance on the front inner slope of the protocone; it connects in front with the parastyle with which the outer end of the protoloph shows a marked tendency to unite. Outwardly the cingulum rises on to the parastyle but does not cross it; it also merges with the mesostyle and metastyle.

M. westoni approaches closely in tooth-structure to *M. latidens* * Douglass (Oligocene of Montana) from which its upper molars are distinguished principally by the presence of the internal cingulum, by the less pronounced parastyle and a proportionately greater antero-posterior diameter with the protoloph more nearly equal in length to the

* *Annals of the Carnegie Museum*, vol. II, No. 2, 1903, New Vertebrates from the Montana Territory by Earl Douglass, p. 161, fig. 7.

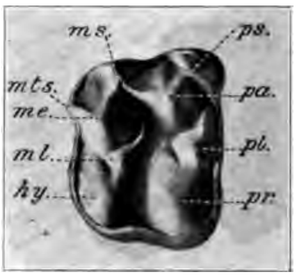

FIG. 1.

FIG. 2

FIG. 3

FIG. 4

MESOHIPPUS WESTONI (COPE).

metaloph, as well as by other characters. *M. celer* † Marsh and *M. montanensis* ‡ Osborn are two other nearly related but distinct species from the Lower Oligocene. The presence of the internal cingulum is the most interesting character in the dentition of *M. westoni.* This character together with the absence of a hypostyle points to this species being probably the most primitive of the known horses of Oligocene age.

No teeth from the lower jaw were obtained during the expedition of last summer. Figures of the two lower molars, discovered in 1884, are given in Cope's memoir of 1891.

Measurments of Upper Molar obtained in 1904.

Transverse diameter	.013
Antero-posterior diameter	.0102
Hight of protocone	.0045
Hight of hypocone	.0045
Hight of ectoloph	.0062

Explanation of figures.

Figure 1. Inferior view of crown of upper molar of *Mesohippus westoni.*

Figure 2. Exterior aspect of the same.

Figure 3. The same viewed from within.

Figure 4. Anterior view of the same.

All the figures are twice the natural size.: *pa.* paracone; *me* metacone; *pr.* protocone; *hy.* hypocone; *pl.* protoconule; *ml.* metaconule; *ps.* parastyle; *ms.* mesostyle; *mts.* metastyle.

EDITORIAL COMMENT.

SUMMER COURSES IN FIELD GEOLOGY.

The joint announcement of summer field courses in geology from which some extracts are given on another page, presents the opportunity for the field study of geology under experienced instructors in various parts of the country for the coming season, in the form most convenient for the inspection of teachers and students at other institutions than those which offer the courses. Courses given

† *American Journal of Science.* (3), vol. vii, 1874. Notice of new equine mammals from the Tertiary formation, p. 261.
‡ 1904, Op. cit.

at the various summer schools, in which instruction is largely given by indoor lectures and exercises, are not included.

A cooperative statement of this kind is in the interest of harmonious competition and of good fellowship on the part of the contributing institutions; and it is particularly in the interest of teachers and students all over the country to have the varied opportunities for field study thus conveniently set forth for their selection.

In order to encourage the taking of field courses in this field science, twenty-five well known colleges and universities authorize the announcement that they will, under certain conditions, give credit to any of their students who take summer courses, even at other institutions. This is a broad-minded development of the inter-university spirit. It is probable that many colleges not in this list will make the same liberal arrangement with any of their students who wish to utilize the summer vacation for geological study.

It has been suggested that the Intercollegiate Appalachian Course for the coming summer be replaced by an Intercollegiate Mississippi Valley course in the summer of 1906. It has been further suggested that a summer field meeting of "Section E" (geology and geography) of the American Association for the Advancement of Science be held at Syracuse, N. Y., in the latter part of the week that the Appalachian course opens in that interesting district. The Sectional Committee has the plan in discussion, with authority from the General Committee to hold summer meetings when and where it wishes.

Since the change of the Association meetings from summer to winter, Section E. had lost the benefit and pleasure of the field excursions that always used to be planned in connection with its sessions, and an experiment in the way of a return to the wholesome habit of field meetings seems well worth while.

WITH REGARD TO PORTAGE CRINOIDS.

In a recent contribution to the American Museum of Natural History bulletin, professor Whitfield has pointed out that the *Cyathocrinus ornatissimus* Hall, which in gold

decorates the cover of the classical report on the Fourth Geological District of New York, is not what I regarded it to be in my memoir on the Naples Fauna. Trusting to the statement which had been made to me by professor Hall that the drawing referred to was raffaelesque and based on various specimens which had passed into the possession of Williams College, I proceeded to describe and figure as the probable type of that species a specimen found in the Williams College collections bearing a label in professor Hall's writing. Professor Whitfield's contention is that the original drawing was essentially true to nature and that the type specimen is in his collection in New York city; consequently that the species which I figured as this is something quite different (I had termed it *Scytalocrinus ornatissimus*) and identical with a new species which he has termed, as type of a new genus, *Maragnicrinus portlandicus*. I am disposed to believe that professor Whitfield is altogether correct in his view of these species values. It was a strange bit of my collecting experience that no trace of *Cyathocrinus* or *Cosmocrinus ornatissimus* was ever found by me in the Portage rocks of lake Erie while the other species was. With professor Hall's statement in my mind I naturally turned to the Williams College museum as the place to find my originals and there they were—so labeled by professor Hall himself.

JOHN M. CLARKE.

Albany, April 3, 1905.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

A Reconnaissance in Northern Alaska, across the Rocky Mountains, along Koyukuk, John, Anaktuvuk and Colville Rivers, and the Arctic Coast to Cape Lisburne, in 1901. By FRANK CHARLES SCHRADER, with Notes by W. J. PETERS. U. S. Geol. Survey, Professional Paper, No. 20. Pages 139; with 16 plates (including 4 maps) and 4 figures in the text. 1904.

This exploration, crossing the great mountain belt and coastal plain of northern Alaska, started from Nulato on the Yukon river, ascended its large northern tributary, the Koyukuk, to its branch

named John river, near the 152nd meridian, and thence extended in a nearly due north course through three and a half degrees of latitude, traveling by canoes, by portage over the Anaktuvuk pass, and again by canoeing down the river of that name and the Colville river to its mouth, with travel thence along the coast of the Arctic ocean through fourteen degrees of longitude west to Cape Lisburne, the northwestern corner of Alaska.

On this route the frontal ranges of the Cordilleran belt trend nearly east and west, occupying a width of about 100 miles, with peaks of 6,000 feet altitude above the sea. To the north a country of rolling plains, the analogue of the Great Plains east of the Rocky mountains in the United States, stretches some 80 miles in width, and is succeeded by a nearly flat low tundra of about the same width, adjoining the ocean.

The Yukon basin, as the author remarks, seems comparable with the great Interior Basin of the western United States; and it may be further added that the southern curving mountain ranges of Alaska, culminating in Mts. St. Elias and Logan, Wrangell, and McKinley, and continuing onward southwesterly in the Alaska peninsula and Aleutian islands, are clearly correlative with the Sierra Nevada and Coast ranges of our Pacific states.

Here the longest mountain series of all the world passes from the western to the eastern hemisphere. Beginning at Cape Horn and running in the Andes and Cordilleran belts along the western sides of South and North America, the same grand orographic features reach forward, beyond Bering strait, through Kamtchatka, the Kurile islands, Japan, Formosa, the Philippines, Borneo, and Celebes, all the series from Patagonia to the East Indies being nearly in the same great circle and having together a length of about 240 degrees.

Metamorphic rocks, principally sedimentary, regarded as of Silurian, Devonian, and Lower Carboniferous age, form the mountain belt crossed by this exploration. It is thought that the metamorphism resulted from the processes of the mountain building, which "seem to have been in progress intermittently since Middle Paleozoic time, and are probably still going on."

Northward, the plains bordering the mountains consist of Cretaceous and Tertiary formations, the former also having a large development southward in the Koyukuk basin, and the latter underlying the tundra region next to the coast.

Glaciation here during the Pleistocene period was not of a continental character comparable with the vast ice sheet of British America and the northern United States; but it was far more extensive than has been heretofore supposed. The mountains were not overridden by moving ice, but were the gathering ground of thick snow and ice fields, whence broad piedmont glaciers, similar to the Malaspina glacier south of Mt. St. Elias, stretched many miles outward to the north and south, into the Colville and Koyukuk

basins. Their drift deposits, largely till, attain maximum thicknesses of 100 to 150 feet.

Ground ice, forming low sea cliffs, sometimes 30 feet high, overlain by a foot or two of muck, which is carpeted with moss and grass, occurs along distances of several miles at Halkett and Simpson capes, midway between the mouth of Colville river and Point Barrow.

Placer gold mining on the head streams of the Koyukuk river has yielded somewhat more than $700,000 during the years 1899 to 1903, this being the only mineral resource utilized in the vast region thus traversed between the Yukon and the Arctic sea.

Bituminous coal and lignite of fair quality have considerable development on the Anaktuvuk and Colville rivers, and also at several localities on the Arctic coast, where coal in beds from 1 to 16 feet thick has been occasionally mined during the past twenty-five years by the crews of whaling and revenue vessels. The coal-bearing formations probably range in age from the Jura-Cretaceous to the Oligocene Tertiary. South of the mountains, the same formations, with veins of coal and lignite, occur on John and Koyukuk rivers, and one coal vein seen on the latter stream has a thickness of 9 or 10 feet.

Snow was found to average about six feet deep in the Koyukuk valley in April, 1901, but two months later it had melted away from the lowlands of that district. W. U.

On the Origin of the Marine (Halolimnic) Fauna of Lake Tanganyika. By W. H. HUDLESTON, F. R. S. Journal of Transactions of the Victoria Institute, London, vol. xxxvi, 1904, pp. 300-351, with two plate maps and four figures in the text.

Lake Tanganyika, about 400 miles long, 2,700 feet above the sea and having a great depth, lying in a very remarkable north to south rift valley or graben, has numerous distinctly marine types of mollusks, crabs and prawns, jelly-fishes, sponges, etc., associated with its ordinary fresh-water fauna. The lake outflows, in its flood stages, by the Lukuga river to the Congo. None of the many other lakes of the same large group, in east central Africa, has such a mingling of species nearly related to marine forms with the fresh-water species.

Mr. J. E. S. Moore, who visited lake Tanganyika in 1896 and again in 1899 for thorough studies and collecting of its fauna, has pointed out resemblances of its halolimnic gasteropods to fossil species of the Inferior Oolite in the Jurassic series of England and France. The author of this paper, however, deems these resemblances inconclusive for derivation of the Tanganyika gasteropods from the Jurassic. More probably the connection of this lake with the sea, and its separation and uplifting of the valley, belonged to a much later geologic period; for the prolonged graben system, in which this valley is a part, appears to date its origin from Middle Tertiary time. W U

Geology of the Vicinity of Little Falls, Herkimer County, [New York]. New York State Museum, Bulletin 77, 1905. By H. P. CUSHING.

The central portion of the Mohawk river beginning west of Schenectady and extending to Utica has cut a deep trench in what professor Tarr has called the Mohawk valley physiographic province, to the north of which the land rises moderately and then sharply to the slopes of the Adirondack mountains. This valley is the eastern gateway between the tide water of the Hudson, at whose mouth lies greater New York, and the great agricultural west. Up the Mohawk valley passed the early explorers and pioneers who built the ancient highways which in time were followed by the Erie Canal and the steam and electric railways. The beautiful scenery of this valley is well known and during the last century has been admired by thousands of travelers between the east and the west. The upper gorge of the Mohawk river at Little Falls has been for many years a region of interest to the physiographer and geologist. This well written and interesting account of 90 pages describing the geology of the Little Falls region by professor Cushing accompanies his geologic map of that quadrangle. It is illustrated by 15 plates, most of which are excellent half-tones, giving views of interesting exposures of the formations or geologic structure; by 14 text-figures and a sheet of colored geologic sections. This region has suffered deformation by faulting which has produced the conspicuous cliff east of Little Falls and the geologic map shows two fault lines near that city and another east of Dolgeville. The Little Falls fault is said to be the most westerly known one in the state with "a throw of nearly or quite 800 feet." To the east of this quadrangle numerous faults cross the Mohawk valley, and the reviewer has shown that the throw of the Hoffman fault, about nine miles northwest of Schenectady, is some 1,600 feet. The geologic map, which is clearly printed, shows areas of both Pre-Cambrian igneous and sedimentary rocks, nearly all the Lower Silurian formations found in the Mohawk valley and Pleistocene deposits. The Pre-Cambrian sedimentary rocks, which are referred to the Grenville formation, are mapped separately. The Lower Silurian formations in ascending order are mapped under the following divisions: Beekmantown formation; Trenton formation composed of the Lowville, Black river and Trenton limestones; Trenton-Utica passage beds and the Utica shale. Considerable attention is devoted to the character and slope of the Pre-Cambrian floor and the evidence of a Beekmantown overlap appears clear and decisive. C. S. P.

Recent studies in the Cambrian of Bohemia.

In connection with the International Geological Congress at Vienna, Dr. J. J. Jahn has published several short articles on the geology of the Palæozoic Basin in Middle Bohemia. One entitled "Geologische exkursionen im Altern Palaozoikum Mittel-Böhmens,"

would be a useful little handbook for a geologist wishing to visit the classical region in middle Europe where Barrande made his important investigations. It contains quite a number of sections of typical localities of the Ordovician and Silurian rocks, and one of the Cambrian.

A short article [from Comptes Rendus IX Congres, géol. internat. de Vienne, 1903] tells of excursions made to the localities named in the preceding article by members of the congress among whom one finds the familiar names of Charles Barrois, L. Dollé, T. de La Touche, C. Wiman and others.

A third article, "Uber die Brachiopodenfauna der Bande d. 1" [from Separat-Abdruck aus den Verhandlungen der K. K. geolog, Reichsanstalt, 1904, No. 12] describes the *Brachiopoda of the lower division of Bande* D at a number of places. This division d. 1 contains the passage beds from the Cambrian to the Ordovician, and the two types of faunas are carefully set forth and distinguished in this paper. Dr. Jahn finds a number of new species of Opolella, Lingula and Discina, which however are not described here.

Another article from the same journal [No. 9] is entitled, *Ein Beitrag zur Kenntnis der Bande d. 1. A.* The rocks enclosing this fauna, quartzyte, graywacke, and clay slate, are described, and the species found at several localities are detailed. Obolus Barroisella, Lingula, Acrothele are the prevailing genera; Orthis and Rhynchonella, also occur.

These articles revise the names of Barrande's genera and will be useful to the student. G. F M.

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CORRESPONDENCE.

PROF. JAMES HALL AND THE TROOST MANUSCRIPT. In professor Glenn's recent biographical sketch of Gerard Troost, published in the GEOLOGIST for February, occurs some reference to his relations with the late James Hall which places the latter in an unfavorable light. As professor Glenn's reference to the matter is not the first that has appeared in print it seems to me well and fair not to perpetuate the statements there given.

Professor Hall was a vigorous spirit in American geology, his productivity was enormous and much of the secret of it was that he could and did lay under tribute to his work so many avenues of supply. The excellence of his achievement and its breadth of scope disturbed many individual and lesser ambitions, and aroused some antagonisms which could not be justified. It is history repeating itself; the towering genius in science sweeps everything before him and human progress rejoices in the result, regarding little the scars of the luckless who got in the way of the triumphal car.

I speak in this way for it is even now necessary to remind younger geologists that Hall was no ordinary figure, that he did his work under circumstances which no longer exist in science, that his capacity for production was not less than his capacity of absorption of others' work and that his excellence was the composite result of all these causes combined with his wisdom in surrounding himself with competent observers whose fortunes he devoted to his own. Hall was ever the target for caustic comment among his countrymen and the repeated published insinuations of peccability constitute a tribute to which he seldom took pains to reply. But it is appropriate to observe that the marks of distinction which he received from the whole world fully equal the sum total of all such honors borne by the American geologists of to-day, and these were gained when honors were not easy.

The Troost manuscript and materials on the American crinoids was, as professor Glenn has said, more than forty years in Hall's possession. It was referred to him by the secretary of the Smithsonian, professor Henry, to pass on its quality before acceptance by the Smithsonian for publication. If accepted the materials on which it was based were to become the property of the government. It was never accepted or recommended for publication and therefore never became the property of the Smithsonian Institution or National Museum. That the latter now has possession is due to no proper right, but rather to the fact that the executors of professor Hall's estate, in their desire to meet every validated claim against it, were not fully advised in this matter.

The entire lack of concern on the part of the secretaries of the Smithsonian Institution in the Troost manuscript is indicated by

the letter of professor Baird to Mr. Meek, already twice published, and by the fact that it was not a subject of more than incidental correspondence between Hall and Henry or his successors. The Smithsonian acquired no title in the property and its secretaries recognized the fact. The documents and specimens, thus, came into the hands of Hall, as the property of Troost; they remained there because they became his own property. I am not acquainted with the proceedings by which this acquisition was finally effected. Doubtless the transfer was gradually worked out and a full equivalent rendered therefor. He has definitely stated that he had acquired the title thereto. Hall was so open-handed in his distribution of the costly volumes of the *Paleontology of New York* as to give the impression that these public documents were for gratuitous distribution. They were not. Hall bought his own copies and he used them as a basis of exchange in the acquisition of materials. There was not in the entire immense collection which his death left among his assets, a single claim which had not been fully extinguished either by payment of money or by transference of copies of his books which had cost him money. By the latter method the Troost title was extinguished and Hall had long before his death acquired full right to use the materials as he saw fit.

John M. Clarke.

Albany, March 20, 1905.

PERSONAL AND SCIENTIFIC NEWS.

The New York Academy of Sciences, Section of Geology and Mineralogy, Meeting of March 6, 1905. Notes on the Minnewaska Region, Ulster Co., New York, by F. Wilton James.

The stripping of the grit from the crest of the second anticline of the Shawangunk* appears to be due to a slight cross fold by anticlinal fracture and erosion, as the rocks at the southwest end of the eroded area show an upward pitch. Through this depression the Peterskill probably flowed while its own valley and Coxing Clove were dammed by the front of the ice sheet, and cut then the Paltz Gap in the crest of the first anticline, 200 feet deep, through which the road to New Paltz now runs.

The basin of lake Minnewaska is vertical-walled except at the southwestern end. The cliffs are highest under Cliff house, where they stand 160 feet above the surface of the

* Darton, Rep. 47, N. Y. State Mus.

lake and 65 feet below it. The grit is probably about 230 feet thick here. The walls are pierced by four crevasses now filled with drift—the remains of two fissures crossing each other at the deepest point in the lake, 74 feet deep. There is no drift in the lake basin, not even under the south-facing cliffs, although the fissure running S. 25° W. is filled, and the transverse breach is blocked to 150 feet above the lake. The glaciation is here S. 10° W. The cause of the absence of drift is not clear; elsewhere the cliffs are heavily skirted.

Lake Awosting lies along a vertical fault plane, drift-filled at both ends. The fault has not been studied. The north wall of the Palmaghat is a vertical fault of 200 feet throw. Both these faults seem to be derived from the overthrown anticline of the Coxingkill escarpment. Mr. Darton is in error in declaring the absence of extended faults.

The next paper was by Dr. A. A. Julien on the "Determination of Brucite as a Rock Constituent."

After a brief review of the life of Dr. Archibald Bruce, of New York city, the discoverer of the mineral, the fact of its wide distribution was set forth, both in limestones and serpentinoids, either in its unchanged condition or in the form of its derivatives, especially magnesite and hydromagnesite, as maintained by Volger in 1855. The following are its most marked characteristics for recognition as a rock constituent.

1. In addition to the known basal cleavage, two other systems may be distinguished on plates or folia; that of the hexagonal prism, often becoming rhombohedral, intersecting at 60° or 120°; and that of the hexagonal pyramid, intersecting at 90°.

2. Nemalitic structure or fibration, commonly occurring in brucite within serpentinoids subjected to dynamic stresses. The major axis of elasticity always lies parallel to the direction of the fibers.

3. Refractive index 1.57, sufficient, when the associated minerals are pure, to distinguish it by the Becke method from serpentine on the one hand and from amphiboles, dolomite, etc., on the other.

4. Birefringence ($\gamma - \alpha = 0.020$) presenting interference colors of the upper first order up to skyblue of lower second order, in plates or sections of the usual thinness.

5. Characteristic strain phenomena; particularly by disturbance of the interference figure, examined by convergent light in basal cleavage plates or folia; also by a variable, small extinction angle in sections parallel to the vertical axis.

6. Optically positive character of the uniaxial figure, in distinction from talc, serpentine, etc.

7. Occasional twinning, observed in crystals enclosed in limestone.

8. Certain chemical tests, in confirmation of the optical diagnosis.

A Joint Announcement of Field Courses in Geology; Summer of 1905, has lately been issued, containing a list of field courses in geology offered for the summer of 1905 by several universities in different parts of the United States.

The colleges and universities named in the list below have agreed, under certain conditions, to give credit for summer field work in geology in such courses as are described in the joint announcement. Students in any of these institutions who wish to take advantage of this arrangement must previously consult the Dean of the department in which they are registered, as to the course that they wish to take and as to the requirements for gaining credit for work done in it.

Amherst College.
Beloit College.
University of Chicago.
Colgate University.
Columbia University.
Hamilton College.
Harvard University.
Johns Hopkins University.
University of Kansas.
Massachusetts Institute of Technology.
McGill University.
University of Michigan.
University of Minnesota.
University of Missouri.
University of North Carolina.
Northwestern University.
Oberlin College.
Ohio Wesleyan University.
University of Rochester.
Syracuse University.
University of Toronto.
Vanderbilt University.
Wesleyan University.
Western Reserve University.
Williams College.
University of Wisconsin.
Yale University.

The number of courses offered and the professors from whom the joint announcement and information about special courses may be obtained are as follows:

Intercollegiate Appalachian Course—Prof. W. B. Clark.
University of Chicago, (Five Courses)—Prof. R. D. Salisbury.
Columbia University, (One Course)—Prof. A. W. Grabau.
Harvard University, (Three Courses)—Prof. J. B. Woodworth.
Johns Hopkins University, (One Course)—Prof. W. B. Clark.
University of Kansas, (One Course)—Prof. E. Haworth.
University of Minnesota, (Two Courses)—Prof. C. W. Hall.
University of North Carolina, (One Course)—Prof. C. Cobb.
Ohio State University, (One Course)—Prof. C. S. Prosser.
Leland Stanford Junior University, (Two Courses)—Prof. J. C. Branner.
University of Wisconsin, (One Course)—Prof. W. H. Hobbs.

The courses announced for relatively distant fields are: Glacial Geology in the Rocky Mountains by Prof. Salisbury of Chicago; General Geology in Montana, by

Prof. Woodworth of Harvard; a visit to Iceland, by Prof. Jaggar of Harvard; two courses at the Minnesota Seaside Station on the Pacific Coast, by Prof. C. W. Hall of Minnesota.

The Intercollegiate Appalachian Course of five weeks' duration, for men only, will be given under the direction of several instructors, as follows:

July 3-8.—Professor W. B. Clark, of the Johns Hopkins University, Baltimore, Md., on the Tertiary and Cretaceous Strata of the Coastal Plain of Maryland; July 10-15, Professor W. M. Davis, of Harvard University, Cambridge, Mass., on the folded Palaeozoic Strata of the Susquehanna-Juniata district of Pennsylvania; July 17-22, Professor T. C. Hopkins, of Syracuse University, Syracuse, N. Y., on the horizontal Palaeozoic Strata and Glacial Features of Central New York; July 24-29, Professor H. P. Cushing, of Western Reserve University, Cleveland, Ohio, on the faulted Crystalline and Palaeozoic Rocks of the Little Falls district, N. Y.: July 31-August 5, Professor J. Barrell, of Yale University, New Haven, Conn., on the Metamorphic and Triassic Rocks of Western Connecticut.

A circular giving fuller details of the course can be had of professor Clark. The work of each week may be taken separately if desired.

GEOLOGICAL SOCIETY OF WASHINGTON. At the meeting of February 22d the following was the program: "The time element in stratigraphy and correlation," T. W. Stanton, with discussion by W. H. Dall, E. O. Ulrich, David White. At the meeting of March 8th the following program was presented: "Subterranean gases at Cripple Creek," Waldemar Lindgren; "Ore deposits of Bingham, Utah," J. W. Boutwell; "An asphalt lake near Tampico, Mexico," W. H. Weed.

At the meeting of March 22d the following papers were presented: "The coal measures of Southern Brazil," I. C. White; "Flora of the Brazilian coal measures," David White; "Tourmaline mines of California," W. T. Schaller.

UNITED STATES GEOLOGICAL SURVEY.

Among the recent publications are:

"Kittanning (Pa.) folio, No. 115," by Charles Butts.

"Geology and water resources of Central Oregon," by I. C. Russell; Bulletin No. 252.

"Report of coal tests made at Louisiana Purchase Exposition," by E. W. Parker, J. A. Holmes, and M. R. Campbell. Bulletin No. 261.

"Lignite of North Dakota as applied to irrigation," by F. A. Wilder. Water Supply and Irrigation Paper No. 117.

"Water powers of Alabama," by B. M. Hall. Water Supply and Irrigation Paper No. 107.

Among the topographic maps recently issued are the following: Ouray, Colo.; Needles Mountains, Colo.

AT THE UNIVERSITY OF NEBRASKA plans are being carried out for the erection of a building to accommodate the department of geology and the state museum, both of which have far outgrown their present accommodations. Hon. Charles H. Morrill has offered to renew his annual donation of $1,000 for the pursuit of geological investigation.

MR. R. V. ANDERSON, a senior in the department of geology at Stanford University, left San Francisco in January for a year's geological study in Japan and China. He accompanies his brother, who is collecting in those countries for the Zoological Society of London.

THE GEOLOGICAL MAPPING of the region about Mount Hamilton, California, will be begun this coming summer by advanced students from Stanford University, under the direction of professors Branner and Newsom.

THE COMMITTEE ON SCIENCE AND ARTS of the Franklin Institute, Philadelphia, has recommended to the Board of City Trusts that Dr. Persifor Frazer be awarded the John Scott legacy premium and medal for his "system of quantitative colorimetry" for determining the genuineness of exhibits of handwriting. (*Science.*)

THE C. L. HERRICK MEMORIAL FUND has been established at Denison University, Granville, Ohio, for the purpose of perpetuating the memory of the late C. L. Herrick. The first purpose of the committee having it in charge is to secure for Denison University Dr. Herrick's scientific library, and later to create a fund for the maintenance of the serials represented in the library, and otherwise to foster the interests of science. A friend has promised to duplicate all subscriptions made, for this purpose prior to July 1, 1905. Contributions may be sent to Prof. Frank Carney, Granville, Ohio.

PROFESSOR ALBERT A. WRIGHT, professor of geology and zoölogy in Oberlin College, died of paralysis on April 2nd at Oberlin, Ohio.

THURSDAY MORNING, MARCH 30TH, BARNEY MEMORIAL HALL, generally known as Science Hall, of Denison University at Granville, Ohio, was burned. This building contained the departments of chemistry, physics, botany, biology and geology and, with the exception of geology, nearly all the collections and equipment were lost. In addition the scientific library of the late Dr. Clarence L. Herrick and that of the Bulletin of the Science Laboratories of Denison University, were burned. The geological department had expended over $5,000 during the winter for additions to its collections and equipment and most of this material was saved. The total loss to the University is estimated as about $95,000, part of which is covered by insurance.

AUGUST MICHEL LEVY, Director of the Geological Survey of France, has been offered the position of professor of Geology and Mineralogy in the College of France, vacant since the death of professor F. Fouqué.

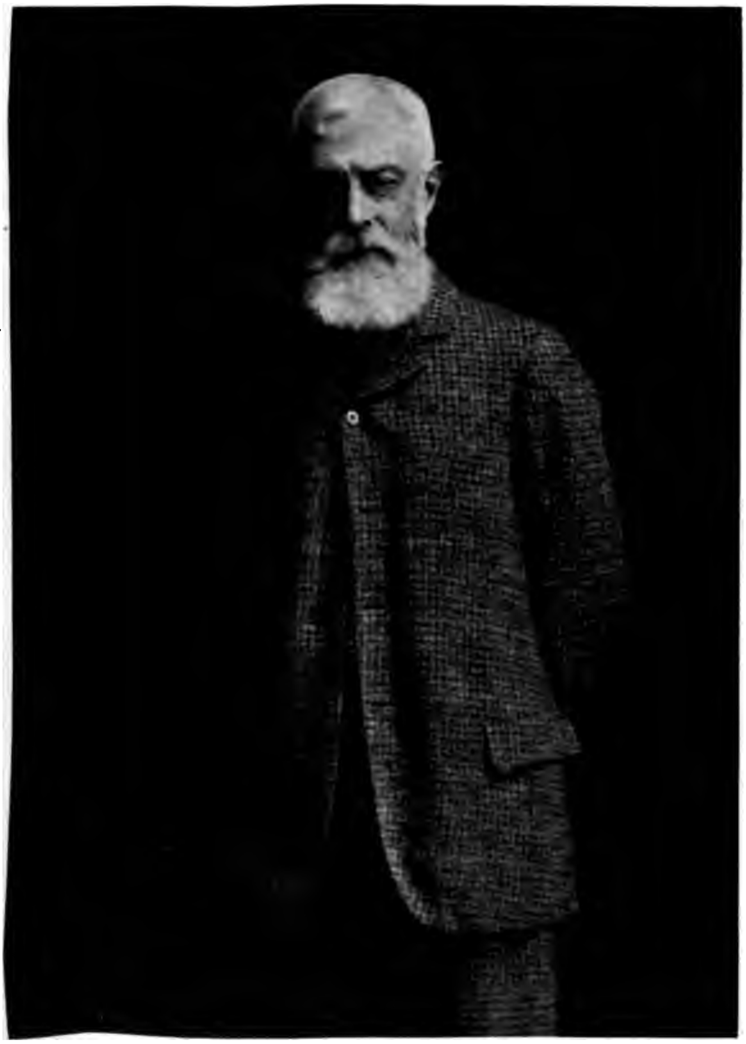
NEW MEXICO GEOLOGICAL SURVEY—The Legislature of New Mexico at its recent session just closed passed a law establishing a State Geological Survey, making an appropriation of $6,000. The work is to be conducted under the supervision of the board of trustees of the New Mexico School of Mines at Socorro. Already considerable new and valuable geological information had been collected.

H. V. WINCHELL, BUTTE, MONTANA, returned recently from an extended tour of examination of the western mining districts. In a personal letter he says, "I saw much of interest in my tour around through Oregon, California and Southern Nevada. Each year's experience only serves to impress more strongly on my mind the great importance of climate and topography, of latitude and geography in the formation of ore deposits. Aside from the presence of eruptive rocks and the subsequent flow of hot waters there are no factors of such importance as climate and topography. Give me the southern deserts where the rocks are slowly altered for ages by surface waters which oxidize faster than they erode instead of the Alaskan and Canadian mountains where erosion is more rapid than oxidation.

Goldfield, Nevada is a busy place but little more than a year old and is 28 miles from a railroad in a desert country. Yet it has electric lights, city water, four banks, many stone buildings and a population of 7,000 or 8,000 people.

It is in the center of a mining camp five or six miles square which seems to have promise of a great future. The ore is in and much associated with rhyolyte dikes cutting andesyte. Water is found at the depth of about 200 feet, and below water the ore contains pyrite, gray copper, bismuth, sulphide, tellurides and free gold. The camp has produced more than two million dollars in gold in 18 months of shipping ore worth over $100 per ton. Other districts around that country such as Tonapah, Bull Frog, etc. are also producing high grade ore and the fortunate discoverers are wealthy before they know it.

At Portland I went to the exposition grounds. They are not immense like those at St. Louis, but very well laid out and the buildings are attractive.



BENJAMIN WEST FRAZIER.

AMERICAN GEOLOGIST,
VOL. XXXV. PLATE XV.

THE

AMERICAN GEOLOGIST.

VOL. XXXV. MAY, 1905. NO. 4.

BENJAMIN WEST FRAZIER.

PORTRAIT—PLATE XV.

This thorough and learned geologist, mineralogist, and metallurgist, was born in Philadelphia, October 3, 1841, and died January 4, 1905, aged sixty-four years, in Bethlehem, Pennsylvania, at the head of the department of Mineralogy in Lehigh University.

It has been the melancholy duty of the present writer to prepare obituary notices of several leading members of our profession in these and other columns, and it has always happened that the study, for this purpose, of each character, has revealed one or more admirable traits which assisted the possessor to his place in the world of science. In the present case the enviable characteristics of professor Frazier, while assisting him to deserve, have hindered him from accepting, the very eminent place as a man of science which is his right.

He entered the sophomore class of the department of Arts of the University of Pennsylvania in 1856, graduating in 1859. The period between this and his departure for Europe was occupied partly in the counting house of his uncle, Joseph Cabot; partly in reading law; and finally, when he had decided upon a scientific career, in preparation at Booth and Garrett's chemical laboratory.

The studies which he had intended should fit him for his profession were interrupted by the civil war of 1861, during the course of which he twice served with the emergency men of the Pennsylvania militia. On the re-establishment of peace he married Miss Alice Clarke of New York, and with his bride visited Europe to attend the best technical schools of geology,

mineralogy, metallurgy, and mining. This took him to the École des Mines at Paris; to Heidelberg; and in 1866 to the Bergakademie founded by Werner in Freiberg, Saxony.

He and the present writer, whose families as well as themselves had always been on the most cordial terms, attended at the same time the same University, subsequently occupied adjoining tables in Booth and Garrett's laboratory, and found themselves again fellow students at Freiberg.

In addition to this parallelism of career the very slight difference in the spelling of their family names and the usual confusion in Saxony between B and P led to many humorous mistakes of identity in which then as now the memorialist regarded as his the gain from such an error. After returning to the United States, professor Frazier engaged for a short time during 1869-70 in the business of sugar refining, but finding business affairs distasteful, accepted the combined chairs of mining and metallurgy in Lehigh University from 1870 to 1880.

His development of the instruction in these subjects was so masterly that it became necessary to separate them. In 1880 he assumed charge of the instruction in mineralogy and metallurgy, which ultimately met the same fate, and professor Frazier finally confined his personal instruction entirely to the subject of mineralogy which, as he interpreted its duties, was as much as one man could attend to.

All this is mere statistics and gives no insight into what the subject of this sketch was actually doing to fulfill the duties of his chairs according to his own high standard. No effort was shirked, no self sacrifice avoided, which could make his courses more perfect. But working thus to satisfy his conscience he seemed to strive equally to keep his labors, and even his high attainments, from the knowledge of the world; in which latter effort he was fortunately not so successful.

It is interesting to inquire, what were the qualities which won the love and respect of all, possessed by this gentleman who never exercised any but a healthy and ennobling influence on his fellow creatures; whose character the present writer, and doubtless many another, has often summoned before his mind as an inspiration when the true path of duty seemed difficult to find.

They would perhaps be best comprehended in the idea associated with the term "religious." They included earnestness, self-abnegation, courage, and the loftiest aims.

It is quite impossible for one who knew him to imagine Benjamin Frazier influenced in word or act by any other considerations than the desire to say that which was entirely true, and at the same time to avoid grieving or injuring others; or failing to give freely and without stint the ripe fruit of his experience for the benefit of friend or stranger who asked any proper question; or influenced by anything but duty without regard to consequences in deciding a course of action; or fixing his eyes elsewhere than on the highest ideals of human conduct, and living up to them so far as a man can. It is not only inconceivable that he ever could have been guilty of a base or unworthy act, but it was impossible for others to be so in his presence or under his influence.

He was extremely sensitive, possessed of an indescribable charm and gentleness of voice and manner which at once proclaimed (in spite of all his modesty could do) the nobility and purity of his character. One found oneself wondering if he had been spared the coarse rough and tumble of most men's lives. He had not, but he escaped the visible scars which such experiences generally leave.

Of course he was a Fellow of the A. A. A. S., a member of the American Philosophical Society, and of the American Institute of Mining Engineers, etc. He could not well help it; and he could not have been a member of any association, however exacting in its intellectual or ethical requirements for eligibility, which his membership would not have honored.

He published numerous papers, all of value because composed with painstaking care and accuracy, and sifted by a clear judgment. Such were those on Air compression, Chimney draught, Economy of fuel in Anthracite blast furnaces, etc. The undersigned was under great obligations to him for his excellent advice as to the new species to be introduced into the fourth edition of Tables for the determination of Minerals. All suggestions of professor Frazier were adopted and together they comprised nine-tenths of all the added species.

The best type of gentleman; a model in consideration for others as in culture, this life brings home to one the fact, which

ought to need no argument, that as the object of science is the attainment of truth, so that of the truest religion as well as the highest philosophy is the regulation of our conduct by this attainment. So far from there being a conflict between these objects no one so successfully pursues either of them alone as both of them together; and this professor Frazier proved.

It is reassuring that such men should be found in this epoch and country, as they occasionally are, resembling intact wax images amongst the blackened ruins of a conflagration.

—*Persifor Frazer, March 24, 1905.*

DEEP WELLS AS A SOURCE OF WATER SUPPLY FOR MINNEAPOLIS.*

By N. H. Winchell, Minneapolis, Minn.

PLATES XVI—XIX.

Introduction. It was thirty-two years ago that I first made observations on the deep wells of the city of Minneapolis. At that time a few wells were active, flowing, and others rose sufficiently high to supply water by pumping. As the survey of the state progressed the conditions of the underlying rocks and their geographic extent were fully ascertained and some of the principles upon which depends the water supply in these wells were definitely learned. It was found that the basins underlying the city pertained to certain definite rock horizons, the outside limits of which are represented upon the map herewith exhibited (Fig. 1). On this map only two of these horizons are shown, namely, that which is 400 feet below the surface and that which is 200 feet below the surface. The former of these basins has an extent north and south from Pine county on the north to Faribault county on the south, and from the southern part of Wright county on the west to the St. Croix river on the east, embracing an area of 10,080 square miles. The thickness of the rock embraced in this horizon is approximately [illegible] feet. Supposing the rock thus embraced to be occupied throughout by one-tenth part of its bulk by water, the number of gallons contained in that res-

* Address of Prof. N. H. Winchell, at the Banquet of the Real Estate Board, February 15, 1905.

ervoir would be 18,919,196,078,220. The upper basin spoken of, which lies at a depth of about 200 feet, extends approximately north and south from the vicinity of southern Isanti county to the central part of Dakota county on the south, and from the west in the central part of Hennepin county eastward to the central part of Washington county, embracing an area of 1,296 square miles. The sandstone in which this water is contained is about 190 feet thick, having an average thickness perhaps of 150 feet. Supposing it to be occupied by water in the same ratio as the other sandstone mentioned, the amount of water contained in this reservoir, would aggregate 4,054,110,793,200 gallons. In order to reach the lower reservoir by a deep well in the city it would be necessary to drill about 400 feet, and in order to reach the bottom of the smaller reservoir it would be necessary to drill about 200 feet.

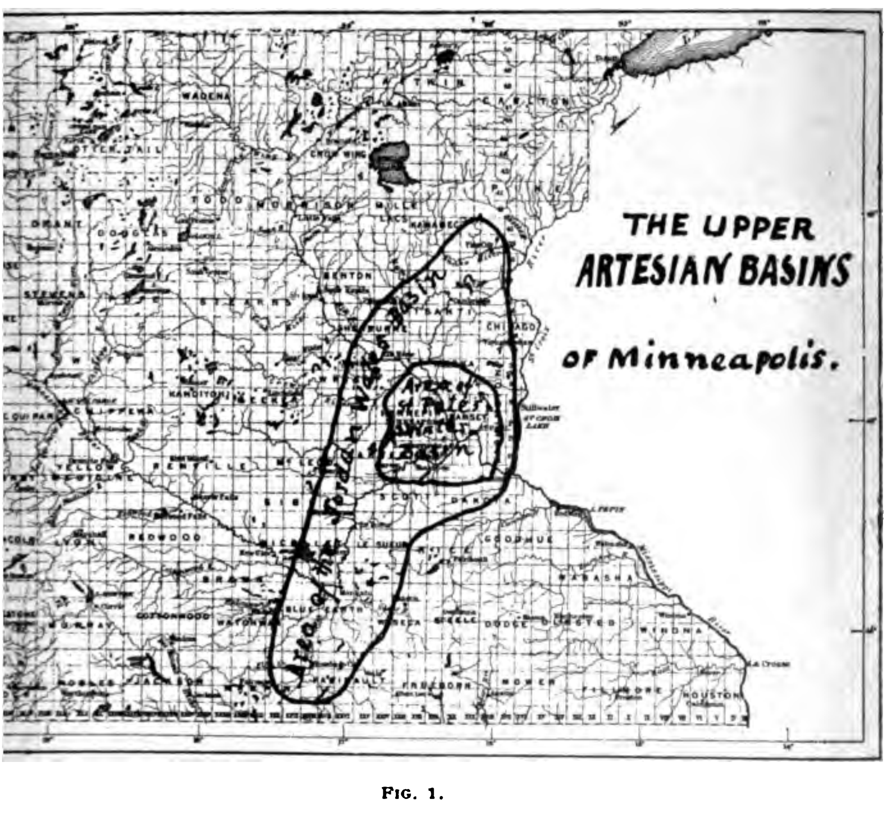


FIG. 1.

The Different Formations Underneath the City.

		Thickness.
1.	Drift	10 to 25 feet
2.	Trenton Limestone	25 feet to 30 feet
3.	St. Peter Sandstone	134 feet to 164 feet
4.	Shale in the St. Peter	1 to 5 feet
5.	St. Peter Sandstone	38 feet
6.	Shakopee Limestone, fissured	25 feet
7.	New Richmond Sandstone	2 to 25 feet
8.	Oneota Limestone	100 to 150 feet
9.	Jordan Sandstone	100 to 140 feet
10.	St. Lawrence Limestone and Shale	100 feet to 125 feet
11.	Dresbach Sandstone and Shale	100 feet to 200 feet
12.	Hinckley Sandstone	175 feet to 200 feet

Conditions of Artesian Water.

It was found in the progress of the survey that these formations which are at a depth of several hundred feet below the city rise gently to the surface in all directions, north, south east and west. For instance, the Jordan sandstone, which is here 450 feet below the surface, rises to a hight of an unknown number of feet above this level in Pine county, and in Sherburne county, and in Blue Earth county. Toward the east in Wisconsin its actual outcrop and elevation need not be mentioned, but it is known to be several hundred feet above the city of Minneapolis.

In the same way the bottom of the St. Peter sandstone which is here 200 feet below the surface, rises into the central part of Anoka county to about 275 feet higher, runs out on the south before reaching Carver, and on the east its lowest horizon is in central Washington county at a hight of 275 feet higher than in Minneapolis. Thus the various strata concerned lie in each other in the form of bowls with the rims rising to the surface at some distance from Minneapolis on all sides. See figure 2, the profile and section from Stillwater to Wright Co.

Any geologist learning this condition of the underlying strata would immediately infer the probability of an artesian flow from each of these horizons at Minneapolis.

Definition of Artesian.

The term "artesian" has been misused and considerably corrupted. It was derived from the city in France named Artois,

where the first flowing well was produced by drilling into the earth. From the city the name has been extended under the term "artesian" throughout all English speaking countries. It is proper that the term should be restricted in its application to only those wells which have a natural overflow; however, in common use, the term has been incorrectly applied to all deep drilled wells, whether they flow at the surface or not. In this discussion we will apply the term "artesian" only to those wells which flow naturally.

The Pending Investigation.

In considering the supply of water for the city of Minneapolis from this rock source the inquiry may be divided into three parts:

1st. Is there sufficient water?

2nd. Is it suitable for the uses of a city?

3rd. Can it be pumped to the reservoir?

1, Is there sufficient water? The calculation which has been made of the cubic contents of the water in two of these basins will convey at the outset a correct idea of the vastness of the actual amount of water contained therein. It would be inevitable, of course, that, however great the amount of water in any basin, it should become exhausted after continued pumping unless there was a continued supply. Therefore, it is not necessary to consider further the actual amount of water but to inquire as to the source of the supply.

The Source of Supply. Did you ever pour a pail of water upon the ground? Did you ever empty a barrel of water upon the ground? Did you ever empty twenty hogsheads of water upon the ground and notice the consequences? If you did, you observed the water running in all directions, sometimes in little rills, sometimes in larger, but ultimately sinking into the earth and disappearing, some of the larger streams running farther and perhaps making little rivulets that ran for many rods before they finally disappeared. What would have been the consequence if the supply which gave birth to these little creeks had been constant? Of course, the answer is self-evident, the earth would become saturated with water and the saturation would be followed by the production of constant streams. Such water as sank into the earth and saturated it would quickly pass through

the porous gravel and sand until it came to clay, which it would saturate less rapidly, and it would appear along the margins of creeks and lakes in the form of springs along the upper surface of this clay. After lapse of sufficient time, however, and owing to many breaks in the continuity of the clay, water gets below the clay and penetrates in the same way the next lower layers and so on to the bottom of the scale until, not only the whole drift, but all of the rocky strata become filled with water.

Now this experiment is only the epitome of what actually occurs in nature. The rains and snows of the year serve as a constant supply to little creeks and rivulets which, uniting, form the rivers. The earth has become saturated to its full depth, including the rocky strata. It is the surplusage of the precipitation of the year which appears first in the form of streams and then in little creeks and then in rivers, which finally reach the ocean. This is a very elementary principle of meteorology and would need scarcely to be mentioned were it not for the fact that the ground supply has been said to be less constant and abundant than the river supply. It is only necessary to say that in case of sufficient drouth the rivers would dry up before the rock reservoirs would, and it would be absolutely necessary to resort to the rock strata for a supply of city water, as is now done in many parts of the western country.

2. *Is It Suitable for the Uses of a City?* I will here call your attention to an important general fact as to the varying qualities of the water derived from deep wells within the city limits, or sunk in the surrounding country into the same formations. For this purpose it is only necessary to mention four principal rock horizons from which water is obtained. The deepest is the Hinckley sandstone, No. 12 of the foregoing section, in which wells are 700 to 800 feet deep; and, secondly, the Dresbach sandstone, 600 feet down; third, the Jordan sandstone, 400 to 450 feet down; and fourth, the bottom of the St. Peter sandstone, about 200 feet down. It is true that water can be obtained, though in less quantities, at many intervening depths, but all of the wells of the city can be roughly classified in these four classes. It has been found that the water coming from the greatest depth is the most highly mineralized, and the water from the least depth is the most nearly soft and pure; hence, the deep wells which reach 700 to 800 feet and those

which reach 600 feet are found to be objectionable for steam-making in boilers because of their hardness, producing a very troublesome scale. Such wells, therefore, have been objected to very seriously and, since they constitute the most used and best known wells in the city, the whole scheme of artesian water has been tabooed on account of the bad reputation of these very deep wells.

The wells, however, which are shallow, coming from the Jordan sandstone or the St. Peter sandstone, afford a water which is not seriously subject to this objection. Chemical analysis of the water coming from say 400 feet, shows that the water is very palatable, is free from sulphureted hydrogen and has hardness not much in excess of that of the river water. I can quote here the following wells to illustrate this character of water: The wells at the North Star Malting Co. and the wells at City Workhouse, at the Home for Children and at the North Star Woolen Mill.

But the wells from the St. Peter sandstone, whether at the full depth of 200 feet or less than 200 feet, afford a water which is still softer. This is probably due to the fact that this water is more nearly like the surface drainage of this part of the state, not having come into contact with contaminating minerals, and is more directly dependent on the Mississippi river. The chemical character of this water is illustrated by analyses of the following wells: Groveland Flats, the Baushfield Wooden Works, Washburn "C" mill, Washburn "B" mill, the C. A. Smith well at Camden Place, and numerous others.

It is quite evident therefore that the water which is derived from the St. Peter sandstone does not differ materially from the spring water which is distributed through the city and sold from wagons, and that it is a little softer than the river water in winter. It is also evident that the water derived from the Jordan sandstone is of a superior quality and fit for all domestic purposes and could be used in boilers, though in some cases perhaps requiring a softener.

3. *Can It Be Pumped to the City Reservoir?* Owing to the existence of these basins below the whole city and extending widely into the country, it is evident that deep wells could be sunk successfully to them at any place in the city limits. Since the water rises sometimes to overflow and sometimes to

short depth below the surface, it is a practical mechanical question whether the water can be handled and can be pumped to the existing city reservoir in northeast Minneapolis. This question is one of hydraulic engineering, which, to a man who does not profess to be an engineer, seems to be quite simple, but it is left to the decision of those who are expert in the handling of water. I would make, however, only this remark, namely, that it seems as if it were as easy to force water from the surface of the ground from these deep wells to the reservoir as to force the river water to the same place.

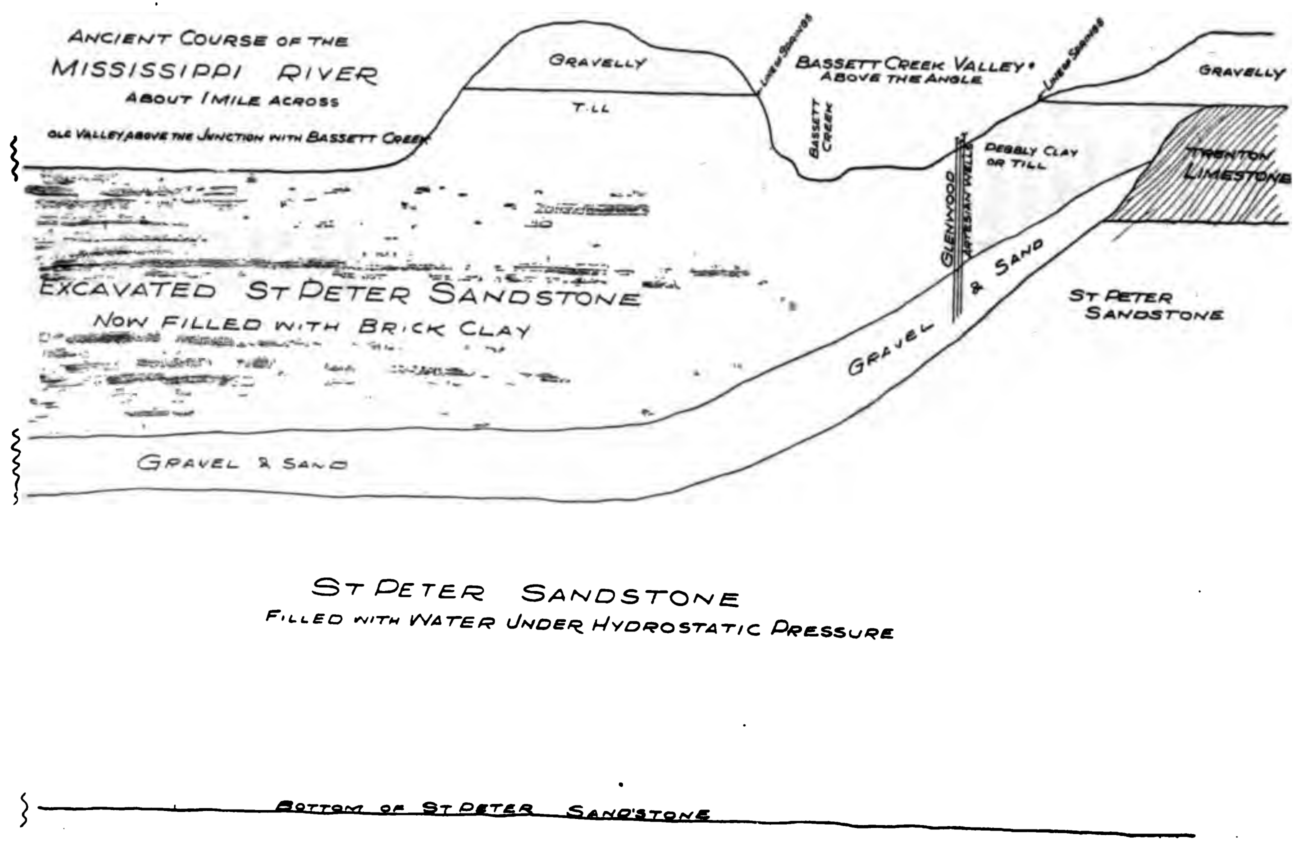
Which Basin Should Be Used?

Owing to the fact that the deepest wells afford a highly mineralized water, and the shallower wells afford a good water suitable for all uses, we will discard entirely further consideration of the water from those deep wells and will concentrate attention upon the wells—say from the St. Peter sandstone. At the present time we take this course—not because the water from the Jordan sandstone is not equally good—but because of the greater availability of the more shallow basin and because of certain variations and interesting complications which attend this basin within the city limits.

Extent and Variations of the 200 Foot Basin.

South of Bassett's creek on the west side of the river and north of Bassett's creek and at a distance from the Mississippi, and in some parts of East Minneapolis, extending slightly into Anoka county and into Ramsey county, the Trenton limestone covers the St. Peter sandstone, but throughout a wide belt extending from the north and turning westward and southwestward through the city limits this Trenton limestone is wanting and of course the drift deposits come down directly into contact with the St. Peter sandstone throughout that wide belt. This wide belt through which the Trenton limestone is wanting is the lower ground; the Mississippi river lies in it from the north boundary of the city to the mouth of Bassett's creek; it then turns westward up Bassett's creek to near the Glenwood Springs at the angle of Bassett's creek. The belt, however, continues westwardly and southwestwardly to the Minnesota valley above Fort Snelling. The beautiful and interesting little lakes in the western part of the city lie in this belt where the

MINNEAPOLIS MINN.



Trenton limestone is wanting. It is found also that the St. Peter sandstone itself is very much reduced in thickness and that there is quite an accumulation of drift materials upon the remaining portion of the St. Peter sandstone throughout this belt. It seems that for a long period of time before the Glacial period the Mississippi river, instead of flowing over the falls of St. Anthony, had a course southwestwardly across the city, occupying this excavated portion of the St. Peter sandstone. This excavation is known to extend northward up the Mississippi valley as far as the St. Peter sandstone is know to extend. The width of this old gorge, if we disregard the drift filling, varies from half a mile to a mile and a half, or perhaps two miles, having an average width at least of a mile.

The drift which lies in this old gorge is frequently a laminated fine clay, having a thickness of sometimes fifty feet. It can be seen at all the brick yards in the north part of the city, and it serves to seal, almost hermetically, the St. Peter sandstone upon which it lies, constituting a barrier against the free passage of water from the sandstone upward or from the surface downward. The area throughout which this gorge is known to exist amounts to 13¼ square miles in the city limits.

The structural relations of the drift, whether it be till or clay, or gravel and sand, to the St. Peter sandstone and to this old gorge are generalized in this diagram:

Fig. .3—Water Relations at the Glenwood-Inglewood Springs.

This diagram shows that the drift, in more or less unmodified state, lies upon the Trenton limestone outside of this old gorge, and constitutes the higher land to the northwest and to the northeast, as well as to the east and west. The surface water which falls upon these higher drift deposits, sinking into the gravel and sand, is shed in the springs at the top of the Trenton limestone wherever the Trenton limestone is extensive enough and impervious enough to shed it in considerable quantity. The surface water which falls upon the brick clay area, sinking into the sands which cover the brick clay, is shed either into Bassett's creek or into the Mississippi.

There are also areas where the till of the drift operates in the same manner as the Trenton limestone and in the same way as the laminated brick clay to confine water and also to shed water. Water which, sinking downward, reaches this till

layer is shed in the form of springs along its upper surface, and water which lies below it is confined under hydrostatic pressure. The detailed relations between the surface waters shed in that way and the water of the St. Peter sandstone which lies below the laminated clay cannot be ascertained. It is known, however, that in many places wells which penetrate the St. Peter sandstone through the laminated clay furnish an artesian flow of excellent water in large amount. It is also known that some wells which penetrate the till of the drift likewise furnish an excellent water in large amount. The chemical resemblance between these two waters will not allow of their being distinguished one from the other, and it is also reasonable to infer that they actually are practically one and the same, especially where the till which furnished such flow lies within the old gorge. Indeed, it seems not only possible but probable that the till here spoken of graduates into the laminated clay imperceptibly and with it constitutes but one sheet of drift, which was modified in accordance with the conditions attending its deposition.

One of the most interesting observations can be made in the valley of Bassett's creek, just above the angle of the creek, at the Glenwood-Inglewood "springs," so-called. The accompanying diagram (above) shows the structural relations between the different parts of the drift and the sandstone, and the different water basins. It can be seen that along the upper slopes of the bluffs which enclose Bassett's creek there is a series of springs, the water of which is shed either by the Trenton limestone or by the till, or by both, these springs being—say—fifty feet above Bassett's creek and furnishing an excellent water coming entirely from the drift deposits. Whether the water of these springs, which is still gathered into pipes and which flows to waste, was ever used for distribution throughout the city of Minneapolis I do not know, but at the present time the water which is distributed to the city of Minneapolis from these "springs" is derived from below the till deposit and it rises above the surface in the form of an artesian water to the hight of —say—twenty feet above Bassett's creek. Several tubular wells have been sunk by the proprietors through the till, which is said to be pebbly but not stony, into a water-bearing stratum of sand. What lies below the sand has not been

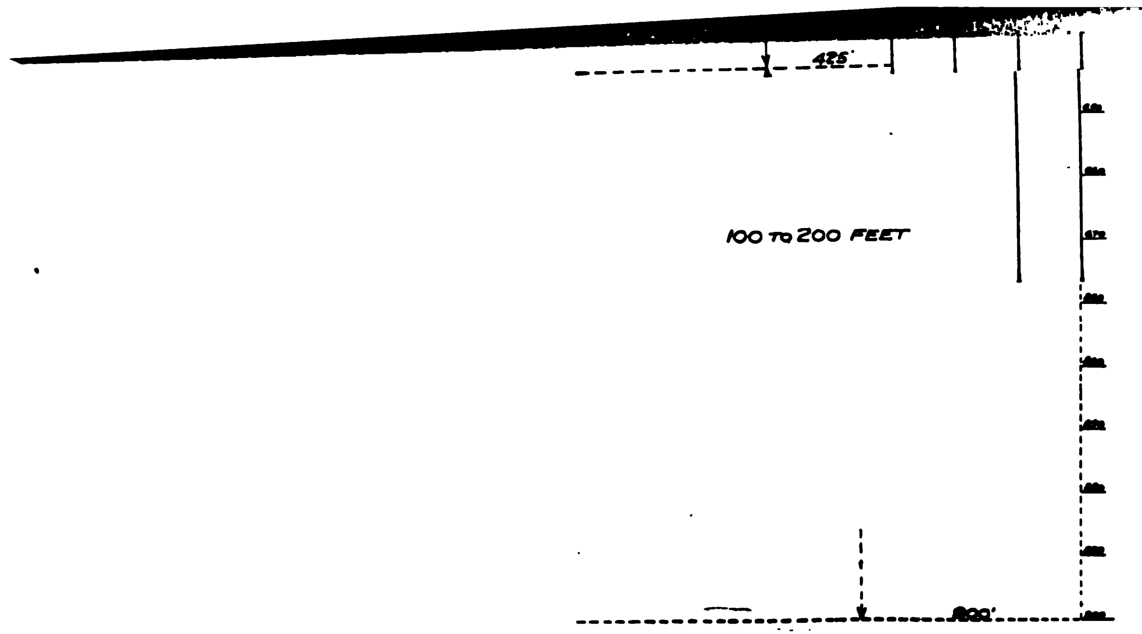
ascertained but of course it is the St. Peter sandstone, and the water contained in the St. Peter sandstone, more or less under hydrostatic pressure at that place, permeates the drift sand and rises through these tubes and overflows at a hight of about, as I said, twenty feet above Bassett's creek. It is conducted in underground pipes and rises to the roof of the buildings adjacent where it is allowed to flow constantly and from which buildings it is conducted into wagon tanks by the simple action of gravity. The capacity, or rather the amount of water supplied, by these "springs" for the city of Minneapolis daily is about 10,000 gallons, and the superintendent stated that they could supply ten times as much if there were a demand. It might also be added that if there were a demand these same little artesian wells could be sunk—say 100 feet deeper, and would furnish perhaps several million gallons daily, and if the number of these wells were increased the reservoir would probably be found inexhaustible, in the same manner as other wells sunk in the St. Peter sandstone.

From what has been stated it will be seen that the water derived from the St. Peter basin cannot mingle with the surface drainage water throughout the area of this belt or gorge formerly occupied by the Mississippi river, that is, not on a large scale. The surface waters are shed either by the Trenton limestone or by the laminated clay or by the till and produce a series of springs which is entirely distinct from any spring which issues from the St. Peter sandstone, although, of course, there may be subterranean seepages and sometimes considerable passages which will conduct the surface water into the underground reservoir even in the limits of Minneapolis. These small seepages downward of the surface water, however, are very inconsequential, since the underlying water is under hydrostatic pressure and the tendency is for the underlying water to crowd upward to the surface, driving the surface waters away. Thus, the subterranean rock basin is kept pure in the city of Minneapolis, not admitting the surface water, while at more remote points, where the St. Peter sandstone rises to the natural surface, it necessarily receives the surface water freely, a fact which has already been mentioned and which constitutes the supply which maintains the underground waters of the basin.

The conclusion to which we are driven, by reasonable consideration of the facts that I have presented, is necessarily that throughout this gorge wells may be sunk through the clay or drift deposits, whatever they may be, and into the St. Peter sandstone, and that they will afford water of the best quality, which will in many places flow over the surface and which will in all cases rise at least to the level of the Mississippi river. The area of this belt amenable to such uses is about 13¼ square miles.

Artesian Water From the Bottom of the St. Peter Sandstone.

I will call your attention now to the diagram (Fig. 4) and especially to No. 4 of that diagram, which represents a shale within the St. Peter sandstone. This shale is sometimes all in one bed and is from one to two or three feet thick, but according to the testimony of well-drillers it is sometimes separated into two or three thinner sheets and is then interlaminated with sand, the whole amounting to perhaps five feet. This shale bed serves as a confining stratum for waters under hydrostatic pressure which are in the St. Peter sandstone below. In some places this shale is represented to be near the bottom of the St. Peter and in other places it is represented to be about thirty feet above the bottom of the St. Peter sandstone. My attention was first called to the existence of this shale and its action upon the waters confined below it by the record of a deep well which I noticed and reported in 1882. It affords an overflow of artesian water in the deep well at the Washburn C mill, so-called, situated near the river on the west side, opposite the falls of St. Anthony. The record states that below the clay or shale is a coarse white sand rock, from which water rises to the surface from the depth of 183 feet. As the water here rises to the surface of the ground there is an indication that the stratum of clay is of considerable extent laterally. This shale bed is probably passed through by every drilled well that goes to that depth. In some cases it is distinctly noted in the record of deep wells, but in many cases it is not noted, the drillers having ignored it. In the West Hotel well this shale was met at a depth of 168 feet, and in the sand rock below it was found the first water at a depth of 178 feet. Shakopee lir stone was then met at a further depth of 24 feet. In this \ also this shale which gave the first water was disregarded.



425'
100 TO 200 FEET
800'

I am informed by Mr. McCarty, who has drilled many wells in the city of Minneapolis and in the surrounding country, and in St. Paul, that habitually water rises nearly or quite to the surface from below this shale. Mr. Hogeland states that he has drilled more than 50 wells in the city which obtained abundant water from below this shale, the water rising nearly or quite to the surface. Mr. McCarty states, however, that although it is impossible to exhaust the water found in this underlying sandstone, in case of hard pumping, the sand itself, which is incoherent, is apt to come with the water and injures the pumps. In order to obviate this difficulty he has resorted to an ingenious method of sinking the well into the underlying limestone (the Shakopee), which he finds is fissured and veined and so open that water usually flows freely into the bore hole. Such water is the same as in the sandstone above, and passes downward into the crevices of the limestone, which acts as a filter and abstracts the sand before it reaches the bore hole. This water-bearing stratum, lying below this shale, is substantially the same water as in the sandstone above the shale, but as a system of wells these should be kept distinct from those of the St. Peter sandstone already mentioned, held under hydrostatic pressure by the brick clay.

While, as already stated, the ground and the rocks underlying are permeated by water and often saturated, there should be made an important exception so far as Minneapolis is concerned. Not only is the drift itself drained sometimes very dry, by reason of the shedding of the surface waters by means of springs into lakes and streams, but the St. Peter sandstone itself is in many places, especially in proximity to the river gorge below the falls of St. Anthony, found to be dry through its upper 25 to 30 feet. The dryness of the St. Peter sandstone of course has to be attributed to the action of the river gorge in draining the upper portion of the sandstone down to the level of the river, below the falls of St. Anthony. At some distance from the river gorge beyond the immediate action of the drainage of the river this sandstone is filled with water.

Objections.

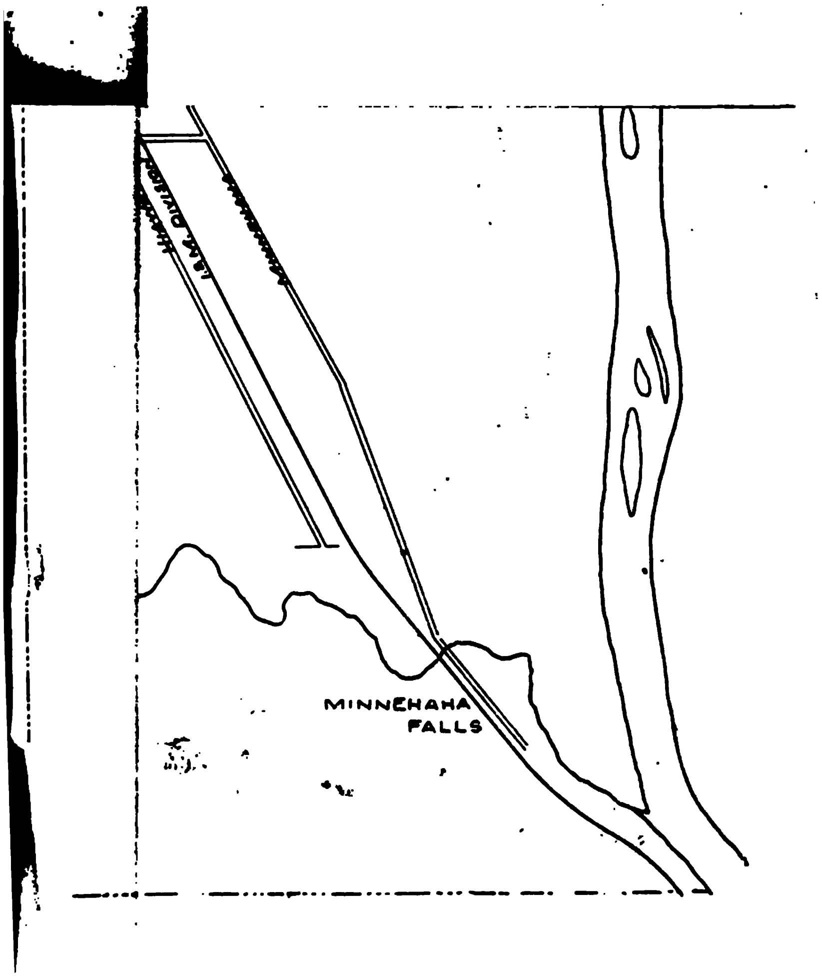
I wish to consider now some objections that have been brought against the idea of deep well water for the city.

Too Hard.—It has already been stated that the character of the water derived from the deepest wells has unfortunately cast a shadow of disrepute upon all the deep well waters of the city. We propose to discard all of those deep wells and thus to eliminate that objection, resorting to the shallower wells, which afford a water substantially like the river water but sometimes more soft.

Not Enough.—It is hard to say from what facts any objection of this character can be derived. There are absolutely no facts that tend to show the limited amount of water in the artesian basin. Probably never was a well sunk the depth of 100 feet in the city of Minneapolis without finding water. At this place I will call your attention to the accompanying map of the city (fig. 5) on which are indicated some artesian wells of the city which reach a depth of not more than 450 feet, and most of which are about 200 feet. You will see that they are widely distributed, and many of them are flowing wells. I have also obtained from some of the well-drillers lists of wells of this kind which they have drilled within the city, namely, a list from Mr. J. F. McCarty, a list from Mr. S. Swenson, and a list from Mr. Hogeland. These lists are herewith appended. Some of these wells are 4 inches in diameter, some are 6 inches in diameter, and some are 10 inches in diameter, and they have been pumped so as to afford the number of gallons per minute expressed in the column at the right. These lists not only give the depth, but the date when bored, the exact locality, the size of the bore hole, the capacity of the well when pumped, the level at which the water stands or overflows, and various other data important in this investigation. It should be stated also that these well-drillers, all of them, state that these lists do not express all of the facts, but that they have drilled probably as many more wells than these listed within the city limits, but cannot give exact data because they kept no records.

Formerly, others made deep wells in the city, viz.: Messrs Whelpley, Spear and Swan, but they are dead or have left the city.

This showing of wells of this kind distributed throughout the city is sufficient to attest the inexhaustible supply which can be obtained from such wells, and to verify the calculation made as to the capacity of these basins based on their geographic extent.


MINNEHAHA
FALLS

Cannot Be Pumped 200 Feet Up.—Some have brought the objection against these wells. namely, those about 200 feet, that there is a mechanical obstacle which cannot be overcome, in the fact, as assumed, that the water must be pumped 200 feet from its starting point, but this objection rests upon a misapprehension of the fact that the water does not have to be pumped from 200 feet underground. It rises to the surface or near the surface and can as easily be pumped as any water at the surface.

Contaminated by Sewage.—It has been stated that the sewers of the city excavated in the St. Peter sandstone below the Trenton limestone would more or less affect the waters that would be derived from the St. Peter sandstone and render them objectionable for city uses. There are two or there misapprehensions involved in this objection. First, the sewers are practically watertight, or become so at least after a

List of Wells Less Than 450 Feet Deep.

[a] **Furnished by J. F. McCarty.**

(Wells are nearly all cased to the Shakopee Limestone and generally not tested at 200 or 250 feet.)

Location and Owner's Name.	When Drilled..	Depth Feet....	Size of Bore. Inches......	Water stands below the surface, or flows...	Capacity in gal. per minute when pumped.	Quality of the water......	REMARKS.
Minneapolis Work House		400	6	Flows	250	Good	In sandrock, north of Camden Place
N. E. Feed Mill, 15th Av. N. E. and Marshall		180	4½	2 feet	100	Fine	In gravel. Cased to the bottom.
S. Korrigan, 1325 Water St. N. E.....		250	6	Flows		Good	In Shakopee limestone.
Despatch Laundry, 26th Av. S. and Stevens Ave.		225	8	30	200	Good	
Mpls. Gas Light Co., 14th Av. S. and river ...		450	10	To the S'rf'ce	350	Good	In sandrock
Mpls. Gas Light Co. 7th St. and Hennepin Av		250	6	40	75	Good	
Home for Children, 31st St. and Stevens Av.	1903	400	6	40	150	Good	
Old Paper Mill, 6th Av. S. and river....		250	10	Flows		Very Good	In sandrock. Not sulphuretted
Phœnix Bldg., 1st Av. S. and Fourth St.		450	8	30	150	Good	In sandrock
W. T. Bras Boiler Works, Division St. & G. N. R'y		100	6	20	50	Good	In limerock. Cased to Trenton. Bored thru Tr
Minneapolis Cold Storage, Nicollet Island..........	1894	400	8	20	500	Good	In sandrock.
Oneida Bldg.		250	6	20	150	Good	In St. Peter sandstone
Minnpls. Knitting Mill, Aldrich and 7th Av. N.		200	6	Flows	200	Good	In gravel
J. F. McCarty, 905 Ramsey St. N. E....		200		2			

[b] From S. Swenson.

Location and Owner's Name.	When Drilled	Depth Feet....	Size of Bore. Inches.......	Water stands below the surface, or flows...	Capacity in gal. per minute when pumped.	Quality of the water.......	REMARKS.
Mpls. Brewing Co., 13th Ave. N. E. and Marshall	1894	450	8	Flows	500	Soft	Flows in basement
N. P. R. R. Co., 10th Av. N and 2d St. ..	1901	328	8	7	500	Soft	In sandstone, cased 169 feet
N. P. R. R. Co. Northtown Junction....	1902	361	8	12	250	Soft	In rock and sandstone, cased to the rock.
North Star Malting Co. 18th Av. N. E. and 2d St.	1901	420	10	20	300	Soft	In sandstone, cased 124 feet
C. A. Smith sawmill, Camden Place	1901	154	4¼	Flows 15 feet over s'rf'ce	100	Irony or soft	60 or 70 ft in sandstone. "Well filtrd river watr"
Baushfield Wooden Works 25th Av. N.E. and Marshall	1904	150	4¼	15	100	Soft	In sand
Gedney Company, 32d Av. N. and First St..	1889	230	6	8	150	Soft	In sandstone
Mpls. Gen. Electric Co. 3d Av. S. E. and Main...	1894	250	8	Flows	800	Soft	In sandstone
Humbolt Mill	1895	450	6	Flows	800	Irony	Flows in the basement
Western and 12th St.....	1893	400	6	Flows	200	Irony	Flows over surface 5 ft
Knitting Works Lyndale & Western.....	1902	343	6	5	175	Elegant s'ft	Pumped with 4½-inch cylinder.
Tho. Basting 13th and Western........	1894	133	3½	Flows	100	Good	Rises 15 feet above surface
Milwaukee Shops Minnehaha Ave.........	1900	114	10	40			Cased off
Milwaukee Shops, Minnehaha Ave........	1900	437	10	30	275	Good	Same as last. Continues to 704. Cased 204 feet
Mpls. Steel & Machinery Co., Minnehaha Ave....	1903	114	10	40			Cased off
Minneapolis Steel & Machinery Co., Minnehaha Av	1903	437	10	30	275	Good	Cased down 200 feet. Continues to 715 feet
S. Swenson, 14th and Emerson......	1891	100	4½	30	Nev'r. tried.	Fine	Through limerock and into sandrock
J. W. Towner, 19th and Emerson.......	1904	60	4½	35	75	Fine	Through limerock and into sandrock
F. A. Gross, Fremont and 14th	1904	74	4½	30	75	Elegant fin'	Through limerock and into sandrock
Crown Iron Works, 19th Av. N. E. & Central...	1903	80	4½	18	75	Fine Soft	Through limerock and into sandrock
Daniels Linseed Oil Co. 28th Av. S. E.. near railroad	1902	143	6	25	100	Fine	Through limerock and into sandrock
F. Delaney, 3022 Fourth St. N.........	1903	157	4½	40	Nev'r tried	Fine	On high ground
John Larson 1202 14th Av. N. E	1902	150	8	30	Nev'r tried	Fine	Probably from the St. Peter. Continues to 658 feet. Cased 100 feet
John Ryberg, 1622 Sheridan Av. N.....	1904	60	4½	30	Nev'r tried	Fine	Through limerock and into sandrock
Wabash Screen Door Co. 22d Av. S. E. and Elm.	1904	152	6	35	75 plus	Fine	"Dandy well" in sandrock
Minneapolis City Reservoir	1895	543	8				On land 200 feet above the city
Central Park	1893	300	6	Flows	Esti. 150	Fine	Flowed into the lake. Probably plugged.

[c] *From other sources.*

Location and Owner's Name.	When Drilled..	Depth Feet....	Size of Bore. Inches.......	Water stands below the surface, or flows...	Capacity in gal. per minute when pumped.	Quality of the water.......	REMARKS.
—— Durgin 4234 Park Boulevard....	1903	181	2	30	All a 2 inch cylindr c'n carry	Fine. No bett'r	
Bryn Mawr Mineral Spring Water Co., 104 Elm St..	1904	91	4	Flows	?	Fine	Sold frm wagons. Went through brick clay.
B P. Munson, 1776 James Av. S. and Douglas.....	1904	144	2	40	?	Fine	On the hill. Water in drift sand.
North Star Woolen Mill		375	6	Fl's 6ft			
McMullen Tannery, Main St.................		200	5	30			
Old Monitor Plow Works, near Laurel Ave. bridge	1877	216	5	6			Sunk by Whelpley
Conkey's Planing Mill, 24th Av. and 1st St. N...	1885	206	6	4			
Thirteenth Av. and Water St. N. E................	1904	96	2	At the surf ce			
King's Flats, Spruce Place and Grant St..	1903	96	2	At the surf'ce			
Lumber Exchange, Fifth and Hennepin.....		350	8	30		Gopd	Hardness "about same as river watr" (Turner)
Washburn B Mill, 5th Av. S. and river	1898	180	2¼	10	U sin' 25	Irony	Near the river at the falls
Pillsbury Washburn Co., 5th Av. S. and 2d St.....	1900	180	2¼	10	U sin' 25	Irony	
Groveland Flats, Erie and Ly nd	1900	172	2½	Fl's at surf ce	30	Soft	Hardness like Riv. wat. or softer. 32ft in sandst
Wm. Langley, Bet. 3d and 2d St. N.E. & 15th & 16th Av.	1892	132	2	3	25 U sin'	Soft	Equal to river water.
Pillsbury A. Mill, near the river gorge...	1896	200	2¼	30	15	Soft	Lowered by the river
Glenwood Inglewood Spring, Western Av.....				6 flowi'g tubulr wls			In gravel under blue clay
Interstate Grain Co.......		150					
Security Elevator.........		75					
Thomas Lowry's Stock Farm...............		260					
Corn Exchange...........		160					
Bardwell-Robinson		240					
J. S. Lane, 625 8th Av. S.E.		290	6	12			
Washburn C Mill, Sixth Av. S. and river..		205	4	Flow d			Was lowered by a new well sunk at lower level
Seward School............	1903	150					
C., St. P., M. & O. R'y Plymouth Ave. yard.....		200					
Boston Block, 302 Hennepin Ave.......		450	6	35			Continued to 675 feet
Rolling Mills, Columbia Heights (Two wells.)		260	8 to 10		P'p'd 20 hrs in 24, 3 in. stream	Exceptʼlly Good	In sandrock (St. Peter) Used in boilers.

NOTE.—Fourteen of these wells give, when pumped for the purpose of testing their capacity, a total supply of 5,400 gallons per minute. An average daily consumption of 30,000,000 gallons by the city requires 20,833 gallons per minute. Hence, if these fourteen wells, ranging from six to ten inches in diameter, were to be increased to the number of 56, they would supply more than the estimated need of the city. In case the wells should average more in diameter their number would be less.

few years of use; second, they are all within the uppermost portion of the St. Peter sandstone, and are below, that is, south of the valley of Bassett's creek, and wells which would be depended upon in that area would necessarily penetrate much deeper than these sewers and would obtain a water from the stratum below the shale which is in the St. Peter sandstone, as already described; third, the St. Peter sandstone operates as a filter to abstract any impurities which might result from the sewers, a filtration which would be many, many times thicker and more effective than any filtration through a layer of sand mechanically formed for the purpose of filtration; fourth, these impurities would necessarily be drained from the surface of the sandstone, if they once entered it and were carried along, into the Mississippi river. They could not permeate the general body of water contained in the sandstone. A current of water goes where it is freest to flow. The surface is the freest and the lightest portions rise to the surface. The body of pure water lying below has the greatest specific gravity and is under hydrostatic pressure and would reject impurities that would have a tendency otherwise to enter the St. Peter sandstone and compel the drainage into the sewers rather than out from the sewers.

This can be illustrated. Did you ever see a peat swamp through which ran a stream? Have you seen the enormous peat swamps in the northern part of the state, particularly that one which is northwestward from Duluth, drained by the St. Louis river? Any bog is permeated by water constantly, and in this great swamp for a width of several townships, but the river flows in its own channel, without reducing the water of the bog in general. It enters at the upper end, follows the channel, passes out at the lower end. It has but little effect upon the water standing in the bog, but, on the contrary, it is affected by the waters of the bog; they pass slowly into the river instead of the river into the bog. In the same manner, a channel of flowing water, as in a sewer in the St. Peter sandstone, would abstract water from the St. Peter sandstone instead of giving water to it. It might, however, be answered here that in the spring of the year, or at flood time, the water does encroach upon the bog and raises the water in the bog, and that therefore the bog is affected by the stream. This, however, is more

imaginary than actual, since the bog, like all the surrounding country, is affected by the flooded stage of the season, and as the river itself rises and has a tendency to overflow, so the bog itself rises with the floods from other sources and tends to reject the overflow from the river and to confine it still within its own channel; this condition, furthermore, is comparable with the sewer channel only when the sewer is completely filled and its contents have a tendency to penetrate its openings; fifth, and lastly, no driller of deep wells would for a moment leave a well uncased in which there was a possibility of contamination from surface waters or from sewers. Such casing is always driven down, after putting a shoe upon the bottom of the tube, until it reaches some portion of the rock so firm that it cannot be driven further, or, until every possibility of surface contamination is surely shut off.

On the north side of Bassett's creek, whether there be sewers or not in the St. Peter sandstone, the sandstone is so crowded with water under hydrostatic pressure, that water would be driven into the sewer, in case of any opening in the sewer, rather than into the sandstone from the sewer.

Too Expensive.—About four years ago the writer delivered an address before the Six O'Clock Club, of this city, in which he set forth these facts and urged the use of artesian waters for the city. He did not touch upon the question of cost of the proposed scheme, but simply set forth the possibilities of ground water and mentioned that a few wells sunk for a test would not cost very much. What was his surprise in next morning's Tribune to find a very flaming account of the expensive proposition which would involve an expenditure of $1,250,000.00, which plan had been submitted to the best civil engineers and to physicians in Minneapolis, who admit its practicability and acknowledge its value "as a broad gauge road to public health." The reporter, who must have been a man of lively imagination, goes on to state that the plan as stated by professor Winchell involved the sinking of ninety wells in order to produce 30,000,000 gallons a day; that the cost of sinking such wells would be, as stated, one million and a quarter of dollars; "but," the reporter continues, "the cost of $450,000.00 would construct a filtration basin and plant against the cost proposed by the sinking of the deep wells; that is, less than half

as much as the proposed project of deep wells, one project being about as efficient, according to Mr. J. T. Fanning, as the other."

Considering the fact that the speaker had said nothing whatever as to the aggregate cost, and considering the recent estimates which have been made as to the cost of a filtration plant, the transparent effort to evade the arguments and to divert attention from the merits of the artesian scheme, as published in the Tribune, seems quite amusing.

I have no definite data upon which a very positive statement can be made as to the cost of a system of deep wells to supply 30,000,000 of gallons per day for the city. I have, however, the estimates of some experienced well-drillers as follows:

Rates for Sinking Wells.

Wells 200 ft. deep, 12-in. bore.................$4.00 per foot
Wells 400 ft. deep, 12-in. bore................ 3.50 per foot
Wells 600 ft. deep, 12-in. bore ....3.50 per foot

It was thought by this gentleman that forty 12-in. wells, at 400 feet depth, cased to—say 150 feet, would supply 30,000,000 of gallons of water per twenty-four hours.

Another gentleman gave the following estimates off-hand:

Wells 200 ft. deep, 12-in. bore................$5.00 per foot
Wells 400 ft. deep, 12-in. bore................ 4.50 per foot
Wells 600 ft. deep, 12-in. bore................ 4.50 per foot

The average well is about 10 inches in diameter. This gentleman estimates that forty 12-inch wells would supply about 15,000,000 or 20,000,000 of gallons per day.

Each of these wells ought to supply half a million gallons per day, and from some a million and a quarter in a 12-inch well has been afforded in a day. This was a test well at the St. Paul works at Centerville lake. If, however, the wells upon which the city should depend were to be in the St. Peter sandstone they would average, say, 200 feet deep, but probably considerably less. According to the first of the foregoing estimates each well would cost $800.00, and forty wells $32,000.00.

According to the second estimate each well would cost $1,000, and forty wells would cost $40,000.00.

Suppose this total is subject to great error and the number of wells should be necessarily more than forty, or that the cost should exceed the amount per foot given and suppose that the

expenses of installing the system and connecting it with the present pumping station were to be included, it would be at least a liberal estimate still to place the total cost not to exceed $100,000.00.

Experience in St. Paul and Other Cities.

St. Paul City Deep Wells.—The water system of St. Paul is primarily one of lakes. By a series of conduits water is conducted from a number of small lakes mostly in the northern part of Ramsey county, but partly in Anoka county, as shown on the map furnished me by Mr. Winslow, of the St. Paul Engineering Department, who has charge of the deep wells operated by the city.

It was found that the supply was insufficient and resort was had to deep wells. There are two systems of these wells, the Centerville and the Vadnais lake systems. A successful test well was sunk at Vadnais lake in 1891, and this system has now increased to ten wells. Of these, seven are shallow wells, not going into the rock but they are deep enough to obtain water from the Jordan sandstone. This system has a capacity of 4,200,000 gallons per day. This water is pumped into the main conduit as it passes from Vadnais lake. Mr. Winslow also gave me a blue print of the ground plan and section of the Vadnais lake system.*

The deepest well of this system was put down last year, and it is in constant use in supplying pure water to the lake water reservoir at Vadnais lake, although the full capacity of the Vadnais Lake system is used only in summer when the lakes run low. The Centerville system was developed during 1896. Here are 28 wells, of which 18 are shallow, depending on the gravel in the surface of the drift for their supply, and 10 are drilled into the rock, obtaining a supply from the Jordan sandstone. These deep wells are 10 inches in diameter, but the shallow wells are 8 inches. The shallow wells are 62 to 100 feet in depth, the deep well from 350 to 523 feet deep, situated along the shore of Centerville lake. Each well, as shown by the accompanying blue print, has a separate connection with the main pipe, making it possible to connect up and test any well, or any number of them whenever desired. The capacity of the Cen-

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*Blue prints were shown.

terville system is not definitely known, but is estimated to be 10,000,000 gallons daily. It was tested with a pump of 15,000,000 gallon (per day) capacity, a few years ago, but was found to be unable to supply that amount. The drift wells were lowered, and the farmers in the vicinity who have numerous flowing wells in the drift complained because their wells ceased flowing, and threatened suit for damages against the city of St. Paul. The pumping was stopped, and since then the Centerville wells have not been used.

The total capacity of the St. Paul deep wells, according to Mr. Winslow, is over 12,000,000 gallons per day, and the average daily consumption from all sources (for 1904) was 9,600,000 gallons. The amount pumped from deep wells in summer into the main conduit is 4,200,000 gallons from the Vadnais lake system alone, there being at present no demand for the Centerville system, which is held as a sort of reserve in case of any emergency. The wells are used even when not needed because of scarcity, in order to cool and purify the lake water, removing the swampy taste and also apparently killing the micro-organisms. The temperature of the well water is 46° and that of the lakes in summer about 70°.

The cost of the St. Paul system at Centerville was $109,000, and of this the outlay for the wells themselves was $20,433, the rest being for piping and pumping outfit and for right of way. I have no figures for the cost of the Vadnais lake system.

It is current rumor at Minneapolis that the St. Paul artesian well system is a failure, and that it is proposed to resort to some other plan of water supply. I made particular inquiries as to the truth in this rumor, and was told that there was no known objection on the score of the quality of the water to the present system, especially the shallow wells at Centerville. If there was any possible objection it would lie against the lake system on account of the swampy taste in summer, and the micro-organisms that develop in it. As to quantity, the city obtains from the Vadnais lake system all that is needed to supplement the lake supply. The idea of abandoning or changing the water system of St. Paul was never broached nor hinted at in the Water Board. This was the statement of Mr. Winslow, who has had charge of the system, or at least has been connected with it, for 14 or 15 years. It is probably safe

to predict that in the future, as in the past, the St. Paul deep wells will increase both in number and in popular esteem.

Stillwater.—McKusick lake has until last year been the source of water for the city of Stillwater. But because of its impurities it has been abandoned and artesian water has been adopted by the city.

Winnipeg.—Owing to reports that the artesian supply at Winnipeg had failed, and that resort was about to be had to filtration of river water, I applied for information to the city engineer of Winnipeg, Col. H. N. Ruttan, asking him certain questions, and from him received the following courteous reply:

The geological situation at Winnipeg is quite analogous to that of the old river valley at Minneapolis, the confining stratum being a laminated clay and till sheet, holding the water in the underlying rock under hydrostatic pressure.

Letter from Col. H. N. Ruttan.

Mr. N. H. Winchell:—

Dear Sir: In answer to yours of the 24th inst., I have much pleasure in sending you copies of reports by Mr. Rudolph Hering and Mr. Allen Hazen on our water supply.

I may answer your questions as follows:

(1) Did the artesian supply give out, making it necessary to resort to river water?

Answer.—No; the supply from our well has been constant in amount since we began pumping some five years ago. The capacity of our well is about 2½ million imperial gallons per day. It has often been pumped in excess of that quantity.

We used river water on the 10th October last, and again on the 26th December to supplement our fire service, and since early in January we have used river water almost daily during the hours of heavy draught.

We now have, almost completed, a new well which we hope will give us plenty of water for our immediate requirements, and last until a further extension of the well system is made, or water is obtained from some other source.

How our supply is to be supplemented depends largely upon the results of pumping at the well and the effect upon test wells which we are sinking.

(2) Is the artesian supply apparently as good as usual, or was it some unusual emergency that overtaxed the wells in operation?

Ans. The artesian supply is quite as good now as it has ever been. The reason it is overtaxed is that our new well has not been completed in time to meet the increased number of consumers.

In 1902, when an extension of our supply was recommended, we had about 3,000 connections. We have now about 7,000 connec-

tions, and from 40,000 to 45,000 actual consumers. The population of the city being close to 100,000.

Had the construction of our new well been completed three months ago, there would not have been any shortage of water for all purposes.

(3) How many artesian wells does the city use?

Ans. One; another being almost completed.

The first well is 17 feet in diameter and 48 feet deep, the bottom containing a strainer of broken stone 5 feet deep with 3 feet of concrete on top, four 6-inch pipes through the concrete admitting the water from the broken stone. The broken stone strainer was necessary to prevent washing the soil from outside the well and undermining our building.

(4) What are their depths and do they enter the rock below the drift of the region?

Ans. The new well is 65 feet deep, the last 16 feet being in the rock. The pump suctions of this well will be 25 feet lower than those of the first well. It is the intention to lower the latter when the new well is in operation.

It is expected that we will get about 5,000,000 gallons from both wells.

The drift is about 5 feet deep on top of the rock. It contains water under pressure, probably received from crevices in the rock.

At the location of our wells before pumping the water stood 3 feet above ground level.

I enclose section of our wells.

Winnipeg is now growing so fast that we consider it prudent to increase our water supply for a population of 200,000, and we are now making investigations as to the most desirable source.

Let me know if I can give you any further information.

Yours truly,

H. N. RUTTAN,

City Engineer.

Chemical Character of Water from Deep Wells, Etc.

Having obtained from Dr. Drew a statement of the results of chemical analyses of numerous waters from deep wells in the city, and having consulted the table of analyses performed by A. D. Meeds for the "pure water commission" last year I am impressed with the capriciousness with which the chemical qualities appear to be distributed, making it quite difficult to draw conclusions as to the quality of water that should be expected from any known well or rock stratum. For instance: Some of the very deep wells afford a water that is (as reported by the analysts) as soft, or as nearly soft, as some of the shallower wells. Compare the water of the Midland Linseed Oil

Company's well with that of the Daniels Linseed Oil well, the former 859 feet deep and the latter 143 feet deep. The total hardness of the shallow well is 22. grains per U. S. gallon, while that of the deep well is but 16.5 per U. S. gallon, which is approximately the same as the river water in winter. A large per cent of the hardness of the shallow well in this case arises from the presence of 69 grains per gallon of sulphuric acid, which is the index of permanent hardness. In other respects they are both comparatively soft waters and do not differ materially from the river water in winter. What may be the source of this large amount of sulphuric acid in the shallow well it is useless to inquire. The Lumber Exchange well, 350 feet deep, has a hardness of 17.5 grains per gallon, a degree which the river water probably never reaches, but which is but little less than that of the West Hotel well, which goes to the depth of 650 feet. Again, the water of the Glenwood-Inglewood springs has a total hardness of 14. per gallon, and that of the North Star Malting Co., 15.5, the former from very shallow wells not penetrating the rock but deriving water from the St. Peter basin, and the latter from a well 420 feet deep. The hardest water reported is that of the Chamber of Commerce, 32 grains per gallon, 550 feet deep, and the softest water is that from the Groveland Flats, 13 grains per gallon, 172 feet deep.

There are other anomalies that might be mentioned. For instance, the element of hardness differs as much as 50 per cent when reported by different analysts, from the same well. Some wells may be cased so that water rises from a different rock from that which expresses the total depth of the well, or may suck water from two or more basins Some may derive water and certain peculiarities from surface contamination. These considerations lead to the necessity of great caution in basing any positive statements on the isolated analyses that are available.

However, from the chemical analyses that have been examined it is safe to draw the following general conclusions:

1. The wells over 450 feet in depth have a greater average hardness than those less than 450 feet, and some of those that derive water from the St. Peter sandstone have about the same hardness as that of the river water.

2. It is very evident also that the removable hardness in the former class (over 450 feet deep), far exceeds that in the latter class. That is to say, the element of sulphuric acid is remarkably greater in the deepest wells, in one well the amount being 137.2 grains per gallon, and the average for eleven such wells being 23.5 grains. But the highest in the shallow wells, i. e., less than 450 feet, is 69.3 grains per gallon; the average of eight wells being 12.6 grains per gallon, or about one-half that in the deeper wells. The amount of permanent hardness in the Glenwood-Inglewood water is 18. grains per gallon.

3. It is reasonable also to infer that the stronger mineralization of the deep waters, as apparent both to the taste and to the sense of smell, is attributable to the presence of this high percentage of sulphuric acid. When fresh, these deep waters often give also a distinct odor of sulphuretted hydrogen. These qualities, however, serve to purify the lake waters of the St Paul system.

It is for these reasons that the discussion which is presented in this paper discards for city uses these deeper wells, and approves those waters coming from the shallower basins.

What Has Been Shown.

If a short resume be made of what has now been shown it comes to about the following:

1st, There are several water basins below the city of Minneapolis, extending widely into the country, of which but two need to be taken ito account, namely, one getting water at about 400 feet, another at about 200 feet.

2nd, The waters afforded by these two basins are not strikingly different in hardness from the water of the Mississippi river, but the water from the shallower reservoir is sometimes softer than the water of the Mississippi river.

3rd, The quantity of the supply is inexhaustible and more reliable than the supply from the Mississippi river itself.

4th, The cost of sinking the necessary number of wells to supply 30,000,000 gallons per day from the 400-foot series need not exceed $100,000.00 at the outside.

Thanks. I need not say that it affords me very great pleasure to have the opportunity of presenting this important question before a committee of the civic societies of the city under the auspices of the Real Estate Board. I have taken considera-

ble interest in the subject of the city water supply ever since I have been in the city, and more particularly since the proposition to install an expensive filtration plant, and I have made some attempts to get the subject fairly considered. I have failed, however, in several of these attempts. The subject had a nominal investigation some ten years ago but the artesian method was practically ignored and an expensive filtration plant was recommended. When the question was revived again recently and a Pure Water Commission was created I communicated with said Commission, sending a letter to the public meeting—which letter, however, was never read—and the subject of artesian water supply was again ignored, and a similar report, making a similar recommendation, was again presented, upon which the question of issuing bonds is now pending, the initial bonds being set at one million dollars.

I have to thank especially Mr. J. L. Record and Mr. Luther Twichell, of the Minneapolis Steel & Machinery Co., and Mr. M. D. Rhame, of the Chicago, Milwaukee & St. Paul Railway, for assistance in the collecting and preparation of the materials of this report.

It is only as a resident of the city and a tax payer, and as a geologist who knows that such expense is wholly unnecessary, that I attempt again to set forth this project with the hope that it may receive due consideration.

EVIDENCE ON THE DEPOSITION OF LOESS.

LUELLA AGNES OWEN, St. Joseph, Mo.

PLATE XX.

Much has been written on loess deposition but those upholding the merits of the two opposing theories have been unable to agree that any evidence yet discovered could be accepted as conclusive. This, however, cannot be regarded as due to deficiencies in the character of the testimony so much as unaccountably wide differences in interpretation. The æolian supporters are not more firm in the belief that original deposition is still in full progress than are those of the aqueous theory that the present is a distinctly separate epoch in geologic history, in which the wind has assumed importance as a "world-power" for the first time. While one assumes that land

snails in the uplands are proof of æolian origin, the other regards them merely as evidence that during the Iowan stage of the Glacial period the spring floods passed sufficiently early for the high lands left exposed to be clothed in vegetation for the maintenance of animal life. Whether the snails whose shells remain were of land or water species is a matter of no important significance, since there is no claim that they have been transported, and the conditions assumed by the aqueous theory are fully as favorable to land forms as to those of fluviatile requirements.

The unearthing of witnesses incapable of opposing interpretations might, accordingly, promote harmony. Several such witnesses together with a few local facts and conditions may therefore be of sufficient interest to merit attention in connection with the "Loess Papers," by professor B. Shimek, recently published as an "Extract from the Bulletin of the Laboratories of Natural History of the State University of Iowa, vol. v."

In discussing the time element, on page 320, professor Shimek says:

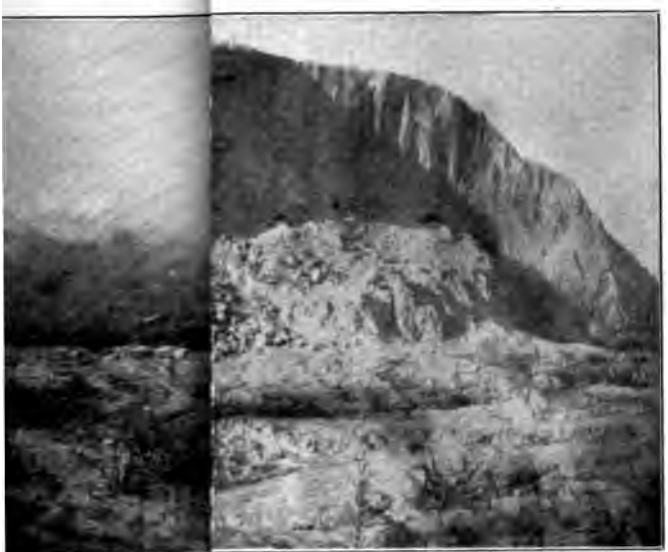
"It might seem that, if loess was deposited most abundantly where vegetation was comparatively vigorous, there ought to be an abundance of plant remains in the deposit. The rate of deposition, however, must have been so slow that all organic matter would have disintegrated long before it could have been covered and sealed in the deposit. Organic remains can thus be preserved only when overwhelmed, especially in wet places, and their absence would rather militate against the aqueous theory."

We may, therefore, feel confident that he would accept any fossilized organic matter as satisfactory evidence that it had been overwhelmed and, consequently, would militate in favor of the aqueous theory.

The loess at St. Joseph has at last yielded this form of testimony. It is the fossil casts of snails in their shells or partly surrounded by the crushed fragments which show to what species they belong. The first discovered is a small group of Helicina occulta, both fully mature and half-grown, that was spread along a horizontal stratification line in original, undisturbed, upland loess at Sycamore, between Fifteenth and Sixteenth streets, in the southeastern part of town. The exposure was made in a street cut and the fossils found at a depth

of about twelve feet below the surface at an elevation of 160 feet above extreme high water. There is no indication that the place could ever have been the bed of a pond, but it must have been the river-bank before the time of the formation of the upper terraces described by professor J. E. Todd, in the Reports of the Missouri Geological Survey, vol. x. An exposure half a block distant shows ripple marks at nearly the same elevation. The loess deposit is very deep here and rises by steep slopes above the valley of the Missouri on the West, and a small permanent tributary on the north which has a well defined ancient valley of its own. While graders were working at Sycamore and Sixteenth streets in the summer of 1903, a large skeleton of an unknown lizard-like animal was exposed and created no little excitement among those present. Some years ago mastodon remains were excavated at a point only a short distance to the northeast and at a slightly lower level, so no one would think of claiming that the region had been continuously submerged, and supporters of the aqueous theory have not been thus inclined. The annual floods, then as now, necessarily attained their excessive stage during the short period in early summer required for melting the vast quantity of snow spread over the region to the north and the enormously extensive water-shed extending far into the mountains on the west and northwest. The balance of the summer gave ample time and favorable conditions for the development and growth of snails on all high points, which were then exposed under moist conditions, while the streams continued to fill their valleys with the normal summer flow from the "great ice" and the more distant regions of perpetual snow. The significance of this western drainage in connection with loess distribution and deposition may not as yet have received its full measure of attention. The wide extent of area and the altitudes of sources of contribution from that direction offer suggestions worthy of special consideration. The southeasterly direction of this flow must have favored a much heavier and more widespread deposition of sediment to the eastward of the current than on the west, the limit of its spread being determined by the resistance met in the volume of flow from the northern ice fields.

An unusually notable exposure of snail shells has been made at Fifteenth and Walnut streets, two blocks southwest of the cut which yielded the casts already mentioned. At a depth of about a foot beneath the surface on the summit of the bluff, at an elevation of 180 feet above, and directly overlooking, the flood-plain, numerous shells were uncovered. At not more than three feet enormous multitudes appeared and a perpendicular cut showed them to be scattered throughout its depth of twenty feet in incredible abundance. Since these twenty feet have been removed the quantity turned up by the plow or exposed by the scraper continues to be surprisingly great. Although there is a general distribution of the shells, the greatest numbers by far are conspicuously in pockets as is almost invariably the case where they are remarkably numerous in previously undisturbed upland loess. As is also usual, those in the pockets are crowded together in a manner clearly indicating that the arrangement was not voluntary; and generally a majority of the shells are crushed into such a mixed mass as to prove beyond dispute that the crushing and burial were one combined act. Frequently the appearance of a shell indicates what surgeons call a "green fracture" suggestive that when crushed it was occupied by the animal, and this is verified by one of the fossil casts of the Sycamore street group. So far only two casts have been discovered among the many shells examined from the Walnut street exposure; but since the number collected were comparatively very insignificant, a satisfactory statement in regard to casts is impossible, although two preserve the historical record as faithfully as more could do. Many of the large shells had the spire completely filled. None had the operculum preserved, and at only one other point has one been found. That was taken from the cut at the summit of King hill soon after the erection of the water-tower. It was examined with keen interest because of the unusual occurrence of a shell perfectly closed by a disk of horny substance totally dissimilar from the calcareous shell. It was doubtless *Helicina occulta*. The unfortunate absolute ignorance of mollusks and consequent want of understanding of the value of the specimen resulted in its loss. A recent thorough search at the same place for another failed of its object but was rewarded with the cast of a *Patula alternata* partly enclosed in a remnant of



the shell into which it had withdrawn and which still retains distinct splashes of color. This cut is 270 feet above the flood-plain and is shown in plate x. in THE AMERICAN GEOLOGIST, vol. xxxiii.

In one of professor Shimek's "Loess Papers," page 334, he says:

"The advocates of the aqueous theory can find little solace in the fossils of the loess, and without them their case has but little tangible support."

This may be true, yet it seems not impossible that both the solace and the tangible support can be found among the fossils of exclusively terrestrial forms, not even those objected to as types common to pools and ponds being admitted to consideration, if the casts already described are to be accepted on the recognized value of such evidence.

The shells collected by professor G. F. Wright from the upland loess at St. Joseph were submitted for identification to professor L. P. Gratacap of the Museum of Natural History, New York. They were taken from the loess about one hundred and fifty feet above the river, and from twenty to fifty feet below the top of the bluff. His report is:

"Group A came from the southeast part of the city, and group B from the north end, and both were embedded in an identical argillaceous dust in which almost no silica and only a slight admixture of lime could be detected."

"The shells are typical terrestrial species but are not in quite the same stage of fossilization, those from the north end of the city having lost the nacre along the columellar surface of the *Succinea obliqua*, which in the same species is partially retained in the specimens from the southeast part of the city. The former specimens were also more frail and tenuous. This difference is unimportant, as local percolation of the surface waters might greatly vary, and produce in shells subjected to, or protected against it, very differing states of preservation."

"Group A consisted of *Succinea obliqua, Patula alternata, Mesodon albolabris.* Group B contained *Succinea obliqua,* and a crushed *Patula striatella.*"

"It would certainly be difficult to draw any conclusive inferences from this meagre display of species. Their general condition of preservation permits a guarded inference that they have not been exposed to rude or distant transportation; they belong where they were found; they are, so to speak, *in situ*. The presence of color flames on the *Patula alternata* argues for its rather rapid sepulture, as the bleaching action of the weather and sunlight would have soon removed these colorations after the death of the animal. On the other hand its own habits of hibernation may have removed it from surface exposures."

"The small size of the *Mesodon albolabris* points to depauperization possibly under the influence of cold, or of insufficient food. The presence of Succinea permits a general assumption of considerable moisture. It is true that *Succinea obliqua* is to-day found in not very moist places, but the aptitude of the organism is for wet spots, and it flourishes best under regional conditions of considerable annual precipitation. *Patula alternata* is disposed to flourish under moist conditions, and generally will not endure a dry climate or position. *Patula striatella* may be safely regarded as a northern and semi-boreal species."

"Conclusions of any diagnostic value cannot be made with security upon such slender representation of shells, but the impression left by them is that of rather boreal and wet conditions of life."

In answer to a request, professor Gratacap graciously consented to examine a larger collection of shells. The forms most abundant in undisturbed upland loess in various direction about town were selected for the purpose but those sent were all from the bluffs to the south and southeast. His determinations are as follows:

Mesodon albolabris Say, fragile, immature, depauperate.

Mesodon albolabris Say, with revolving striæ destroyed.

Mesodon albolabris Say, immature, weak, cold conditions.

Patula alternata Say, color splashes, thin, depauperate, indication of cold.

Patula alternata Say, color splashes; probable burial or voluntary sepulture before long exposure.

Helicina occulta Say, quite normal.

Succinea obliqua Say, normal, flourishing individuals.

Succinea obliqua Say, average forms but shrunken, cold conditions.

Succinea obliqua Say, very small, pinched and starved individuals.

Cast, enclosing Succinea.

Commenting on them he says:

"In regard to any light these specimens throw on the question of aqueous or æolian conditions I must frankly say that they, to me, seem to offer no decisive evidence."

But he also says:

"The flamings and color patches on the "alternata" are certainly quite vivid and indicate burial. It does not seem to me that æolian deposition of necessity should be extremely slow. Certainly dust storms of any continuance would make deposits of very considerable thickness in a short time. As regards "alternata," however, it may be recalled that the animal craves moisture and does not readily endure dryness. It also buries itself in captivity. The color marks are usually more striking and deep if the animal has enjoyed normal moist conditions—and therefore it would be reasonable to suppose that the preservation of the 'flamings' indicates a normal habitat. Aridity would seem to be assured by the æolian theory."

If only a few of the "alternata" retained the vivid flamings their testimony might, possibly, be regarded as of doubtful value, but since they may easily be collected by thousands and faded specimens are rare, it would appear quite safe for the advocates of the aqueous theory to find a little solace in them, as well as the casts, and accept both for a very tangible support of their case.

A small collection of fossils from the same sources had previously been sent to Dr. Theodore Gill for his identification. None of the flaming *alternata* were included. He referred the shells to professor Bartsch to determine exactly, and returned them with the report rendered and the assurance that all the species are living land shells, although some of the Succineas are "very like fresh-water limnæids." The species reported are: Circinaria concava Say; Polygyra multilineata Say; Succinea avara Say; Succinea grovenorii Lea; Succinea lineata Lea.

The specimens submitted by professor Wright were mainly taken from greater depths in the bluff than those of the other two collections.

The *Circinaria concava* and the *Succinea avara* are by no means so abundant as the other forms, while the *Succinea obliqua* is the most numerous everywhere and is found at greater depths than any other form in cuts that penetrate far into the bluff or through it, and they are now living in shallow water in the deep ravine north of the fossil bearing hills, but not elsewhere in that vicinity. Yet in the highest portions of the upland loess the *Patula alternata* and others of the lists given are everywhere associated with it and are of almost equal numbers.

These high elevations are doubtless the land areas which produced the terrestrial mollusks,—when the waters were not at flood stage. It is reasonable to suppose that then as now there were, within certain limits, considerable variations as to time, duration and stage of the annual flood; these being dependent upon such variable conditions as the amount of both winter snow-fall and spring rains, and very largely on the direction of the winds. If the winds persist in the north until late spring the "June rise" must bring "extreme high water" of short duration but so late as to destroy early vegetation on

submerged areas and insures a less luxuriant late growth,—unless the snow-fall was less than average. On the other hand a heavy fall of snow may be carried out by degrees in long time if south winds keep the rivers open, or open them early, and "chinooks" make winter visits to the snow fields. In the present year the ice broke up at St. Joseph on the last day of February and the stage of the river increased four feet in twenty-four hours, since when the excess of snow is going out in March. And the March winds are denied access to professor Shimek's poor little source of supply for the double range of stately bluffs. It might also be considered doubtful if the most extreme stage of high water was of regular annual occurrence.

A reasonable search for the "sand-dune areas" in the vicinity of St. Joseph has not met with success, if they are to be identified by any similarity to the sand dunes of northwestern Nebraska or New Mexico, or those of Holland. If there is a resemblance anywhere it is only in the loose surface soil, of æolian origin, that often caps the hills and covers slopes to a depth, usually not much greater than the length of grass roots, or fills sheltered depressions. Dunes might equally well be sought along the Rhine or on the banks of the swift-flowing, yellow Yangtse-kiang, where its loess deposit is extending the Chinese coast line and driving back to sea.

The river bars having been credited with a lavish generosity in contributions to bluff building so greatly in excess of their visible available means, it may be acceptable if they are cited to show that where the floods have had greatest influence the areas so affected are not rendered at all unfit for such plant life as snails require. It is a fact well and positively known to dwellers on the Missouri river that in an incredibly short time after the surface of the bar becomes exposed there springs up a thick covering of willows and succulent plants which develop with extreme rapidity. If the floods pass early in the season, the willows form dense thickets, or "brakes," that shelter the tender undergrowth from the summer heat and protect the bars from æolian erosion until swept away by the next season's flood. The bars, accordingly, when so covered might be expected to retain a quantity of dust brought to them from other sources. If however, the river maintains a

high stage until so late in the season that this covering of vegetation fails, then the period of æolian erosion is extremely short; and after so long a wet season the winds are seldom high. The development of land snails on high lands subject to similar submergence and plant growth is not so much a mystery to be explained as a sequence to be expected. In regard to their term of life, S. P. Woodward says:

"Land snails are mostly biennial; hatched in summer and autumn, they are half grown by the winter-time, and acquire their full growth in the following spring and summer."

These frail animals are known to inhabit, or infest, all countries save the arctic regions, to thrive in altitudes from sea level to seven thousand feet, and to successfully resist or defy extermination. Their habits of hibernation certainly gave them protection against the cold of winter and their survival of general floods may be accounted for, possibly, in more than one way. It is known to naturalists that they can endure submergence while in hibernation but the limit of such endurance seems not yet to have been determined. Dr. Johnson says:

"There is something admirable in this curious adaptation of the economy of the hibernating creatures to their situation; for otherwise they could not live beyond a single summer in the countries which they now inhabit with impunity to themselves. If, during their active state of existence, you were to keep a Limneus, or any other aquatic pulmoniferous species, immersed in water for only one short day, or even for little more than an hour, it would die irrecoverably; but it remains under water, perhaps with the surface frozen over, for three or four months uninjured, when the system has been prepared in autumn for the change. And so of the land kinds; they perish if deprived of air for a few hours only in summer, or if exposed to an artificial cold not lower than the cold of winter; but in a state of hibernation they respire, if any, such a small quantity of air as not to be appreciated, and brave our longest and severest frosts without peril and without pain."

Many may have also survived among the uprooted willows and other growths that may be seen floating as rafts on a Missouri flood, and soon anchored in masses to a stranded tree or snag. Large quantities of eggs might also be carried short distances in nests held securely among the fibrous roots. Roots of any considerable size float above the water.

The question of sustenance is an even more simple one to dispose of when we consider that snails are by no means fastidious and actual starvation is not a serious menace. Of diet Dr.

Johnson says: "The land tribes seem to refuse no tender herb;" and in another place:

"On occasions they eat voraciously; but, when necessary, they can sustain a fast longer, perhaps, than any other animated beings: snails having been kept for upwards of a year, nay, for years, and the Limnäeæ and Planorbis for many months, without any food, except that small and tenuous portion which they might extract from the air and water."

The same author referring to herbiverous mollusks occasionally zoophagous, says:

"The pulmonated gasteropods have a strange hankering after flesh, and become very cannibals in satisfying this propensity. Lister asserts that snails will eat flesh of all kinds, particularly fish and salted meat; and that having once placed an individual of the *Helix aspersa* with another of the *Arion ater* in a vessel together, he found on the following day, that the former had slain the slug, and had miserably torn and eaten its skin."

And also that—"In the absence of other nourishment, they will even devour each other, piercing the shell near its apex, and eating away the upper folds of its inhabitant. This accounts for the mutilated and often imperfectly repaired state of the upper volutions of some specimens."

So it would seem that under whatever conditions and temporary changes the loess snails existed their wants were sufficiently provided for, if the one condition of aridity be excluded. Even that can be endured in a torpid state in climates where the alternating rainy season affords ample opportunity for propagation and development; but if they passed half the year in hibernation on account of cold, and the other half in the torpor demanded by aridity, even such prolific creatures as snails must have shown a steady decrease as the bluffs grew in hight instead of the very marked increase that the hill-tops proclaim.

MISSOURI PALAEONTOLOGY.

By R. R. Rowley, Louisiana, Mo.

PLATE XXI.

Cyathocrinus formosus, n. sp.

Fig. 1. Side view of the type, natural size.

Calyx elongate conical; underbasals five, large and occupying nearly a third of the hight of the calyx. Basals large, six- and seven-sided. Radials hardly as large as the underbasals, with a broad scar above to receive the first costal. Each upper sloping edge of the bifurcating second costal supports a series of three radials of a higher order. Here again the third plate is bifurcating and supporting a third order of radials. As the rays have lost little in width at this hight, it is probable they were much longer and bifurcated a number of times more. Just above the single large anal plate and inclosed by three other plates above is a round anal opening, apparently near the base of a short anal tube.

The ornamentation of the body plates is low, sharp, radiating ridges and little nodes, the striæ being almost parallel. A slight ridge follows the free rays and this, with nodes, constitutes the ornamentation of the arms.

An inch of stem is attached to the specimen, made up of alternate larger and smaller joints set with nodes, like circular-saw teeth. The central canal of the stem is strongly five-lobed. The underbasals of our specimen extend upward to some hight instead of being "spread out" or "with a slight upward curvature," per generic diagnosis, and again the basals are much larger than the radials, contrary to Wachsmuth and Springer. The type came from the top of the Lower Burlington limestone at Louisiana, Mo.

Cryptoblastus melo O. & S.

Fig. 2. A lateral view of a crushed specimen to which two or three segments of the column are attached. The first segment seen outside of the base is somewhat larger than the next, and completely covers the basal concavity.

Fig. 3. A view of the anal (?) interradius of another specimen in which a large elliptical plate, nearly a third of the body in length, lies below the deltoid, thus giving two interradials to the area. This plate has a convex surface in strong contrast to the valley-like suture line of the radials.

Both specimens are from the top of the fourth division of the Lower Burlington limestone, Pratt's quarry, Louisiana, Mo.

Schizoblastus sayi Shumard.

Fig. 4. Ventral view of an imperfect specimen showing the extension of the ventral covering over the ambulacral furrows of two areas. In fact these furrows have been covered in all five of the ambulacra and only recently have the roofing plates been removed as shown by the calcite still filling the furrows like little rods. The two areas that still preserve the covering show the furrow to be arched over by a neat little roof, the ambulacrum appearing like a blunt ridge. We have this same feature exhibited on two or more specimens of *Orophocrinus stelliformis,* the roofing extending to the very ambulacral tips as has been the case in the specimen of sayi before us.

The specimen came from the base of the Upper Burlington limestone, Pratt's quarry, Louisiana, Mo.

Lophoblastus pentagonus, n. sp.

Fig. 5. Basal view of the type specimen, natural size.
Fig. 6. Ventral view of the same specimen.
Fig. 7. Side view of the type.
Fig. 8. Ventral view of the same specimen, four diameters.

The three basal plates of the usual blastoid shape, form a low conical convexity quite half the greatest diameter of the body. The length of the radials is more than half the body length and their width is two-thirds their length.

The interradials are long enough to be well seen on a side view. The pore pieces of the rather narrow ambulacra have all been removed from weathering, thus exposing the lancet piece, full length. The ambulacra are not sunken but form strong rounded ridges whose distal ends are so far from the radiobasal sutures that a basal view gives a rather strong stellate appearance to the fossil. The anal interradial has been removed but the anal opening was probably above medium size and bounded on the outside by a hood-like projection. The spiracles are ten rather elongate openings. The spade-like inner areas of the interradials are depressed at their centers like miniature finger prints.

The surface for the attachment of the column is rather small and the columnar canal minute and apparently round. The ornamentation is probably delicate longitudinal ridges as in other species of the genus but our specimens are not in a condition to show this feature. The collection contains four specimens, two from Bowling Green and two from near Curry-

ville, Mo. The figured specimen is from the Chouteau limestone of the former place.

Eretmocrinus nodosus Rowley.

Fig. 9. Side view of the body of a specimen differing somewhat from the type of the species.

Eretmocrinus nodosus was figured and described in Vol. XXV, February, 1900, AMERICAN GEOLOGIST.

The figure on the accompanying plate is of a more elongate but less nodose specimen, occurring, however, in the same horizon as the type.

Base layer of the Upper Burlington limestone, Pratt's quarry, Louisiana, Mo.

Amplexus archimediformis, n. sp.

Fig. 10. Side view of the type specimen, natural size.

The type specimen as it lay half imbedded in soft white chert, looked strikingly like the axis of an *Archimedes.* Owing to the very thin and delicate character of the frill-like expansions and the difficulty of removing the matrix without injuring the specimen, the fossil has been but little cleaned. The body is very slender, elongate, often twisted or distorted, constricted in places and surrounded at irregular intervals by thin, broadly expanded calicular-like growths. There are no external appearances of either septa or tabulæ, but it is almost certain from stems apparently of this species, split lengthwise, that the septa are merely superficial, leaving the greater part of the stem diameter as a cavity divided into chambers by tabulæ extending entirely across the latter, arranged like the external expansions at irregular intervals, but not very close together.

The calyx of the type cannot well be cleaned without destroying the outer-cup wall, but was obviously a deep funnel with a thin and greatly expanded outer wall, almost smooth both on the inside as well as on the outside, the lamellæ hardly visible at the bottom of the cup around the edge of the tabula. This peculiar coral occurs about seventeen feet below the *Orophocrinus stelliformis* horizon of the Lower Burlington limestone at Louisiana, Mo.

The type came from the Duff Green quarry and is from a white chert nodule.

Other specimens from the Pratt and Cole quarries.

Monilopora amplexa Rowley.

Figs. 11, 12, 13, 14, 15, 16. Showing joints of crinoid columns girt about by this peculiar coral.

Fig. 19. A large, long column with a great swollen zone occasioned by two or more girdling corals.

Figs. 17, 18. Swollen stems produced, no doubt, by parasitic guests as apparently indicated by pits and shallow depressions.

This coral was originally described in the June, 1901, number of the AMERICAN GEOLOGIST, under the name of *Aulopora amplexa.* It undoubtedly belongs to professor Grabau's genus, *Monilopora* and is refigured on the accompanying plate to show the manner of growth and to account for certain protuberances and enlarged sections of crinoid stems often noticed by collectors in the Burlington limestone.

From most of the accompanying figures, it is evident that the coral attached itself to the stem of the living crinoid and there lived and grew until it was enveloped by the growing stem.

Like the sting of an insect to the twig of a tree, the girding *Monilopora* on the living crinoid stem gave rise to an excrescence or enlargement of the column.

In figure 11 we find a healthy young coral encircling a small, round stem joint that never grew after the attachment of the coral or, less probable, the stem was dead when the coral began its growth.

In Figure 12 the coral was, perhaps, dead before the crinoid stem ceased to grow, so also in figures 13 and 14, as evidenced by the broken *Monilopora* cups, and stem as well, in figure 15.

In figure 13 the after growth of the crinoid stem has entirely surrounded the girding stem of the coral and has almost done so in figure 14, the cup ends of the coral appearing as entrances to tunnels.

In figure 15 the *Monilopora* has been destroyed after the separation of the crinoid stem from its head and has left a circular passage around the stem, broken into in places.

In figure 16 the crinoid column and coral have grown together and perhaps died together as the *Monilopora* cups are entire despite the fact the crinoid column has enveloped the coral stem.

Figure 19 is a round, rather large stem that has been girt about by apparently several colonies of *Monilopora* and has enlarged itself greatly about the region of attachment by external growth that has enveloped and, doubtless, destroyed the parasites.

Figures 17 and 18 are swollen stems with pits and depressions due either to *Monilopora* or some boring organism.

One crinoid stem in our possession less than a quarter of an inch in length has two girding *Moniloporae.*

Conical pits often thickly cover the surface of enlarged stem joints and occasionally plates of crinoid bodies, giving rise, in the latter case, to warty protuberances, but the origin of these pits is as yet unknown to the writer.

A calyx of a *Cactocrinus* before us has every plate covered by the mouths of small pits.

It is a little surprising that this *Monilopora* grew only on crinoid stems and nine out of every ten of our specimens gird *Platycrinus* stem joints. Evidently there was a preference for the stems of the latter genus.

Two crinoid columns before us are noticeably constricted by girding *Bryozoa,* incrusting the stems at those places. Figures 11, 16 are of specimens from near the middle of the Lower Burlington limestone. The rest are from the top of the Lower Burlington, while the collection contains many from the base of the Upper Burlington and the top of the Chouteau limestone (at Fern Glen, Mo.).

Locality, Louisiana, Mo.

Orophocrinus stelliformis.

Fig. 20. Aspect of the ventral side of a natural cast.

The specimen figured is the only natural cast of this species ever found by the writer and shows some interesting features. From the central pentagonal opening radiate five bifurcating canals with an apparent semicircular canal about the center.

The ten elongate, spiracular slits appear as elongate, elliptical elevations, the hydrospires being faintly outlined only near the distal ends of the ambulacra. The anal opening also appears as a slight elevation between two ambulacra.

The specimen is from a chert nodule of the Lower Burlington limestone, Pratt's quarry, Louisiana, Mo.

Orophocrinus conicus? W. & Sp.

Fig. 21. Side view of a specimen apparently of Wachsmuth and Springer's species.

The specimen is beautifully ornamented by lines parallel with the plate sutures. It is but little lobed at the summit, with ambulacra of medium width and the body slightly constricted just below the region of the radio-basal sutures.

The specimen came from the third division of the Lower Burlington limestone, Pratt's quarry, Louisiana, Mo.

A form very similar to this has been found near the top of the fifth division.

Orophocrinus stelliformis? O. & S.

Figs. 22, 23, 24. Side and summit views of a beautiful little specimen from the soft white chert.

It is probably the young of *O. stelliformis,* though it differs somewhat from that species. The body is but little lobed above and terminates in a basal handle below. The ambulacra are short and broad being distinctly petaloid. The spiracles are elongate slits while the anal opening enters the test in such a way as to make a sharp dent in the peripheral outline. The central opening is covered by a roof of small plates that extends down each ambulacral center almost or quite to the distal extremities.

From the *Cryptoblastus melo* horizon of the Lower Burlington, Cole's quarry, Louisiana, Mo.

Pentremites conoideus Hall.

Fig. 25. Side view of a very large, inflated specimen with a base not visible in this position.

Fig. 26 is somewhat like *P. elongatus* in outline but is a true *conoideus.* It came from the Warsaw beds of Mount Newman, Kentucky.

Contrast with the next figure, an elongate specimen with a protuberant base. These represent the two extremes in *conoideus,* but they are not entitled to specific distinction.

This is unusually rotund and does not show the usually marked difference between the diameter near the summit and that at the distal ends of the ambulacra. This specimen was obtained from the Warsaw limestone at Grand Tower, Illinois.

Metablastus lineatus Shumard.

Fig. 27 is an injured specimen with a portion of the column detached and lying near by on the slab. The diameter of the stem scar at the base of the blastoid body is the same as that of the detached col-

umn and leaves no doubt of the correctness of the reference. The stem segments are very thin and of uniform diameter, together forming a perfectly smooth column.

Third division of the Lower Burlington limestone, Cole's quarry, Louisiana, Mo.

Metablastus bipyramidalis Hall.

Fig. 28 is a small specimen preserving the delicate pinnules. It is from the Keokuk beds at Boonville, Mo.

Metablastus lineatus Shumard.

Fig. 29. Side view of a small specimen from the third division of the Lower Burlington limestone. The specimen is from the soft white chert and preserves the test.

Fig. 30. Side view of a natural cast from the Upper Burlington chert.

These two figures are intended for comparison with other species of Burlington blastoids of the elongate form, figured on this plate.

Figure 29 is beautifully striate under the lens. A cast of this species in our collection is over two inches long and in size rivaled either *wortheni* or *bipyramidalis.*

Burlington limestone, Louisiana, Mo.

Codaster gracillimus Rowley.

Figures 31, 32. Side views of the type and a much smaller specimen, natural size.

These specimens are figured here for comparison with other elongate forms. Like *Codaster grandis, C. laeviculus* and the new form, *C. superbus,* this species has hydrospire slits in all five of the interambulacral areas and, according to Ethridge and Carpenter's classification, would be a *Phaenoschisma.* The surface is beautifully striate and the specimens came from the soft white cherts of the third division of the Burlington, Pratt's and Cole's quarries.

The chief characteristics of this species are its slender form almost flat ventral region, narrow ambulacra, very fine hydrospire slits, very elongate basal plates (from a half to two-thirds the length of the fossil), sharply angled character of the basoradial sutures at their junctions.

Mesoblastus kirkwoodensis? Shumard.

Fig. 33. Side view of a small but plump specimen.

Fig. 34. Ventral view of the same specimen.

This is the rarest blastoid in the Boonville beds and the specimen figured is the only plump one the writer has seen. Of four other specimens in the collection, all are much larger than this one but crushed out of shape. The test seems to be very thin.

There is some doubt about the correctness of this reference, since *M. kirkwoodensis* comes from a higher formation, the St. Louis limestone. Also, our specimens are less concave at the ventral or top end, but otherwise agree fairly well with Dr. Shumard's species.

In the Boonville beds there is a strong commingling of Keokuk and Warsaw fossils.

Keokuk-Warsaw limestone, Boonville, Mo.

Codaster superbus, n. sp.

Fig. 35. A natural chert cast of the visceral cavity of the type specimen, side view.

Fig. 36. Ventral view of the same specimen showing the hydrospire slits, ambulacra and other features.

The basal plates are quite half the body in length and form a pyramidal cup.

The radials extend to the ventral surface, the interradials being very small and not visible on a side view.

The very narrow ambulacra are short and occupy the bottom of rather deep valleys whose sides are crossed by fifteen or sixteen hydrospire slits each or from thirty to thirty-two to the area.

These slits are crowded, parallel with each other and the ambulacrum.

As in *Codaster grandis*, the slits occupy both sides of every inter-ambulacral area, thus excluding both these species from the genus *Codaster* as rediagnosed by Ethbridge and Carpenter.

The anal opening is not large and the central area, usually open in most species of blastoids from the fragile character of the covering plates, is closed in this specimen.

As in other species of the genus, the ornamentation is fine lines parallel with the plate sutures. The stem was small and the perforation minute. The type came from a piece of chert not in place but, from associated fossils, evidently belongs to

the upper part of the Upper Burlington limestone, much above the horizon of *C. grandis.*

The type specimen is quite an inch and a quarter long and much the finest species of the genus.

Upper Burlington chert, Louisiana, Mo.

Codaster laeviculus Rowley.

Fig. 37. Side view of a specimen, a little flattened, as it lies partly imbedded in soft earthy limestone.

Fig. 38. A typical natural cast of this species from chert.

Fig. 39. Side view of a natural cast from chert, probably a variety cf this species.

Codaster laeviculus differs from the other Burlington species of this genus, greatly, in its broad, petaloid ambulacra covering completely the hydrospire slits, and in the possession of five rather large heart-shaped openings at the junction of the ambulacra, near the central opening.

It is doubtful whether it could be ranged under *Phaenoschisma.* This is rather a puzzling form, possessing characteristics of several genera.

It occurs in the very basal layer of the Upper Burlington limestone and cherts of the same horizon.

Specimen 37 is from Pratt's quarry, Louisiana, Mo.

Codaster grandis Rowley.

Figs. 40 and 41. Side and summit views of a medium sized specimen. A natural cast from chert.

This is a very handsome species and is figured here to complete the Burlington species of the genus.

Its rotund form with a broad ventral surface and slender ambulacra at once separate it widely from the other Burlington species.

Three limestone specimens came from the basal layer of the Upper Burlington limestone in Pratt's quarry, while the specimen here figured was found near Curryville, Mo., and the type specimen from a chert on the hillside, west of Louisiana.

While there is some resemblance in outline between *Codaster laeviculus* and *C. superbus,* the latter has many more hydrospire slits to the area than the former, and, in fact, more than any other Burlington species, except *C. grandis.* The narrow

ambulacra and greater size also are specific characters of *C. superbus.*

Note.—The discovery by the writer of granular surface ornamentation on the plates of both dorsal and ventral cups of certain well-preserved Burlington crinoids, usually considered smooth, has led him to believe that this granular character is rather the rule than the exception and he is not surprised to add to his list other granular species from time to time. The list at present embraces, *Agaricocrinus brevis, Eretmocrinus coronatus, Baltocrinus subaequalis, Steganocrinus sculptus, Agaricocrinus bullatus, Agaricocrinus wortheni* (from the Keokuk) and several species of *Megistocrinus* and *Dolatocrinus* (from the Devonian).

EXPLANATION OF PLATE.

(*All figures except figure* 8 *are drawn natural size.*)

Cyathocrinus formosus, n. sp.

Fig. 1. Side view of the type as it lies on a slab, natural size.

Cryptoblastus melo O. & S.

Fig. 2. A lateral view of a crushed specimen showing two or three of the top stem joints. Natural size.

Fig. 3. A view of the anal interradius of another specimen showing an extra plate below the deltoid.

Schizoblastus sayi Shumard.

Fig. 4. Ventral view of a specimen showing a central roof of small plates that extends out over the ambulacra.

Lophoblastus pentagonus, n. sp.

Figs. 5, 6, 7. Basal, summit and side views of the type. Nat. size.
Fig. 8. Ventral view of the same specimen, four diameters.

Eretmocrinus nodosus Rowley.

Fig. 9. Side view of a fine specimen, natural size.

Amplexus arkimediformis, n. sp.

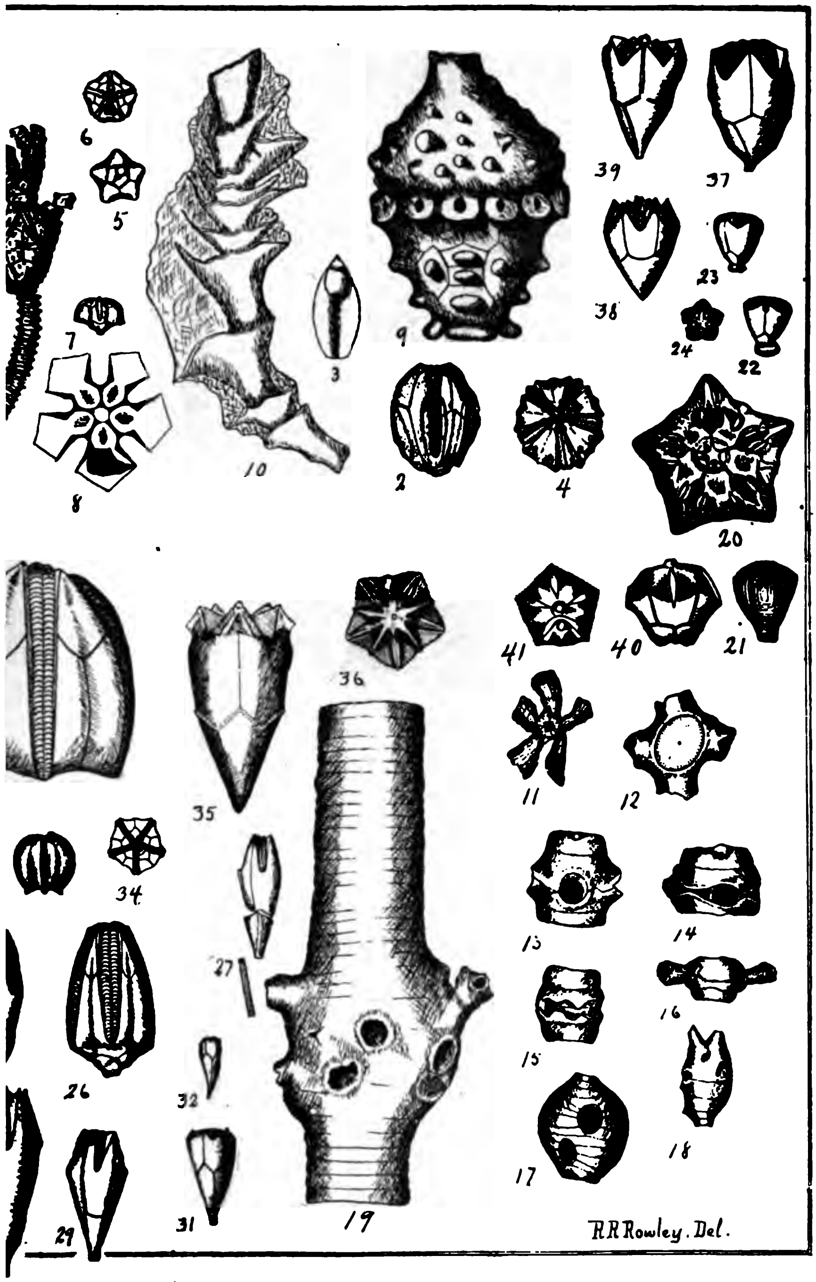
Fig. 10. Side view of the type specimen, natural size.

Monilopora amplexa Rowley.

Figs. 11, 12, 13, 14, 15, 16. Stem joints surrounded by Monilopora, natural size.
Figs. 17, 18. Smaller stem joints with pits and depressions.
Fig. 19. A large crinoid stem enveloping Monilopora. Nat. size.

Onychocrinus stelliformis O. & S.

Fig. 20. Ventral aspect of a natural cast, natural size.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Orophocrinus conicus? W. & Sp.

Fig. 21. Side view of a specimen apparently of this species.

Orophocrinus stelliformis? O. & S.

Figs. 22, 23, 24. Side and summit views of an apparently young specimen.

Pentremites conoideus Hall.

Fig. 25. Side view of a robus specimen with slightly concave base.
Fig. 26. Side view of an elongate specimen with convex base.

Metablastus bipyramidalis Hall.

Fig. 28. Side view of a small specimen preserving the pinnules.

Metablastus lineatus Shumard.

Fig. 27. Side view of a small specimen, with detached column near.

Fig. 29. Side view of a small specimen, preserving the test, natural size.

Fig. 30. Side view of a medium sized internal cast, natural size.

Codaster gracillimus Rowley.

Figs. 31, 32. Side views of two different specimens, natural size.

Mesoblastus kirkwoodensis? Shumard.

Figs. 33, 34. Side and summit views of the same specimen, natural size.

Codaster superbus, n. sp.

Figs. 35, 36. Side and summit views of the type, a natural cast, natural size.

Codaster lacviculus Rowley.

Fig. 37. Side view of a specimen preserving the test, natural size.
Fig. 38. Side view of a natural cast of this species, natural size.
Fig. 39. Side view of a natural cast, doubtfully identified, natural size.

.*Codaster grandis* Rowley.

Figs. 40, 41. Side and summit views of a natural cast, natural size.

FJORDS AND HANGING VALLEYS.

By WARREN UPHAM, St. Paul, Minn.

From Denmark and Norway we receive the word *fjord*, designating any long and often branched inlet of the sea, inclosed in Denmark by shores of only moderate hight and gentle slopes, but in Norway having steep or occasionally precipitous shores, frequently of mountain hights.

If we retain the foreign spelling of the word, as here, instead of anglicizing it to *fiord*, its unique orthography tells the reader that it is of Scandinavian origin, bringing to mind the grand Norwegian fjords, the longest and deepest in the world, one of which, the Sogne fjord, extends more than a hundred miles inland, has many branches, is enclosed by cliffs and plateaus about a mile high, and has a maximum depth of 4,080 feet beneath the sea level. The reader is also obliged by that original spelling to pronounce *fjord* as a monosyllable, and learns that the *j* has the sound of our *y* as a consonant. Etymologically this word is nearly akin with the Scottish *firth* and *frith*; and it is to be remarked that some of the fjords or friths of Scotland have low shores, as in Denmark, while many others are like the awe-inspiring fjords of Norway.

Thus it is seen that the term *fjord* is well applicable to the inlets of the relatively low coasts of Maine, the eastern provinces of Canada and Newfoundland, and to Puget sound and all its branches, though immediately inclosed by land of no great altitude. Generally, however, this name, in most regions for which it is commonly adopted, as for the majestic Saguenay river, and in Labrador, Greenland, all our Artic archipelago, and Alaska, on the coast of British Columbia, and in Patagonia and New Zealand, signifies a deep but narrow inlet of the sea, in a deep valley or gorge, with steep and very high shores.

Continuing inland, the fjord, valley, gorge, or cañon, is occupied by a stream, to which other streams are tributary from each side. Likewise the arms of the longer fjords, and the

landward continuations of their valleys, show a perfect analogy with river systems. Therefore Dana, a half century ago, in 1855, in his address as the retiring president of the American Association, explained the fjords as channels eroded by rivers when the lands so indented stood higher than now, at altitudes measured by the depths of the fjords now beneath the sea; and at the same time he sagaciously ascribed the cold of the Glacial period to such increase in the elevation and extent of northern lands.

An argument lately urged against the river-erosion of the fjords, and instead, referring these deep, narrow, and often irregularly bending, zigzagging and branching valleys, channeled far beneath the level of the sea, to ice-erosion, is drawn from the frequently discordant junctions of their relatively small tributaries. On each side of the deep fjords, and in like manner on the sides of deep inland valleys of glaciated areas, the small inflowing streams often occupy mature upland valleys, which have gentle descent until near or at their debouchure into the main valley, where they suddenly fall off hundreds of feet to join the trunk valley or bed of the fjord. These high tributary stream courses, having so remarkable discordance, have been called *hanging valleys* by Gilbert and Davis; and other geologists and geographers have generally adopted this name for these significant topographic forms. It is argued by Gannett,* Gilbert,† Davis,‡ Hubbard,§ and others, that glaciation of the main valley or fjord cut it down so far beneath its former land surface, while the small tributary valleys were only slightly lowered by the feebler glaciation there, the ice being thinner and having slower motion.

But against this theory of glacial erosion of great valleys and fjords beneath the levels of the small hanging valleys, strong reaction and remonstrances have yet more recently

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*Henry Gannett, "Lake Chelan," National Geographic Magazine, vol. ix, pp. 417-428, 1898.

†G. K. Gilbert, "Glaciers and Glaciation," Harriman Alaska Expedition, vol. iii, 1904.

‡W. M. Davis, "Glacial Erosion in France, Switzerland, and Norway," Proceedings of the Boston Society of Natural History, vol. xxix, pp. 273-322, July, 1900. This paper contains a bibliography in its last two pages; and it notes the first use of the name *hanging valleys*, as proposed in 1899 by Gilbert, on page 288.

§George D. Hubbard, "Fiords," and "On the Origin of Fiords," Bulletin of the American Geographical Society of New York, vol. xxxiii, pp. 330-337, and 401-408, 1901. (Prepared as a thesis in Geography, under Prof. W. M. Davis, at Harvard University.)

been voiced by Tarr,* Fairchild,† and Russell,‡ with whom I confidently concur. In numerous places where glaciation had been supposed to account for the over-deepening of the trunk valleys, it is shown by these writers that insuperable objections oppose such an explanation, that the ice-erosion was of small amount in comparison with river sculpture and weathering, and that similar relations of cañons and hanging valleys occur in regions which have had no glaciation.

Epeirogenic uplifting of great areas, comprising large parts of continents, rejuvenating the principal streams so that they cut down their channels rapidly, while the little tributaries lagged in their downward channeling, seems to me the general and acceptable explanation of the very deep valleys, cañons, and fjords with their lateral hanging valleys.

No more certain conclusion in the science of geology has been attained than the uniqueness of the Ice age. For this period of quite unusual and unexampled conditions in climate and snow and ice accumulation, some equally extraordinary causes must be sought. It is found, as I believe, in the epeirogenic elevation of the areas that were glaciated. The measure of their uplift, or a part of it , is supplied by the depths of the fjords, which cannot, as I think, be logically referred to ice-erosion, but must instead, be due to river-channeling. They show, according to this view, that the glaciated lands had been raised thousands of feet higher than now, until their elevation brought a cold and snowy climate. While they were being uplifted, and during the early part of their elevation, the large rivers cut down rapidly and deeply, but the small brooks and rills wore very little and remained in hanging valleys, an anomaly and puzzle for geologists.

With ice envelopment of these areas, the valleys were moderately glaciated, their sides being much smoothed, but probably receiving little or no addition to their depth. Finally, un-

*Ralph S. Tarr, "Hanging Valleys in the Finger Lake Region of Central New York," AMERICAN GEOLOGIST, vol. xxxiii, pp. 271-291, May, 1904. "The Gorges and Waterfalls of Central New York," Bulletin of the American Geographical Society, vol. xxxvii, pp. 193-212, April, 1905. Professor Tarr, ten years before, had attributed Lake Cayuga and others of the Finger lakes to glacial erosion, on the evidence of their high lateral tributaries (Bulletin, Geological Society of America, vol. v, pp. 339-356) ; and his latest testimony in favor of stream erosion as probably the chief agency in the channelling of these remarkable lake basins is thus his more mature conclusion.

†H. L. Fairchild, "Ice Erosion Theory a Fallacy," Bulletin, Geological Society of America, vol. xvi, pp. 13-74, February, 1905.

‡Israel C. Russell, "Hanging Valleys,'" Bulletin, Geological Society of America, vol. xvi, pp. 75-90, February, 1905.

der the vast weight of the ice-sheets, the lands were depressed to their present levels, or mostly even somewhat lower; temperate climatic conditions were thus restored, the ice being melted away; and the fjords testify to the depth of the land subsidence and marine submergence, accompanying the departure of the ice, and continuing to the present time.

In some instances, however, deep valleys and discordance of their tributaries are doubtless to be explained by the displacement of faulted segments of the bed-rock, as noted by Crosby.*

Further evidences of late Pliocene and early Pleistocene epeirogenic elevation of northern land areas and sea beds, shown by entirely submerged fjords or continuations of river valleys, and by beds of littoral marine shells dredged at great depths, have been adduced by Spencer, Hull, Brögger, Nansen, and others, including the present writer. Many years since, in 1889, in an appendix contributed to Wright's "Ice Age in North America," I reviewed the evidences then known of very high land uplifts as the principal cause of the Glacial period, tracing also the supposed relationship between the crust and interior of the earth which could admit of so great epeirogenic movements. No better explanation of the causes of glaciation seems to me to have been brought forward; and it has gained new and strong support by the latest discussions of the origin of fjords and hanging valleys, in place of the distrust which in the minds of some students beset this view a few years ago.

The early suggestion of Dana thus seems still sustained by advancing research, namely, that three grand continental movements of glaciated regions characterized the Glacial and Recent periods, first, great uplifts which induced the ice accumulation; second, subsidence of the ice-burdened lands, bringing again a mild climate and ending the Ice age; and, third, moderate reëlevation, lifting coastal parts of the sea-bed to be again a land-surface. The epoch of great uplifts, doubtless most prolonged far northward and far southward, was the time of deep fjord erosion, and ensuing lateral planation of the fjord cliffs by rasping ice, the little tributaries being left high above the wonderfully deepened main valleys.

*"The Hanging Valleys of Georgetown, Colorado," Technology Quarterly, vol. xvi, pp. 41-50, March, 1903; also in the AMERICAN GEOLOGIST, vol. xxxii, pp. 42-48, July, 1903.

abundant illustrations and maps, what is known of the underground water conditions of a large tract of country, from the south line of Kansas to the central part of South Dakota, and from Iowa to the mountainous regions of Wyoming and Colorado. In making such a summary it becomes necessary to embrace a vast mass of details already known, and to condense them to a birdseye view, so directed as to bring out the salient features of topography and geology but at the same time to show most clearly the water resources. This object is very fully and admirably accomplished. The geology of the whole area is sketched in 189 pages, this part embracing the greater number of the photographic plates. The general water conditions of the whole area are sketched and the deep wells and well prospects of the different states are then given in some detail. The maps, and especially the generalized stratigraphic sections, are well conceived and well executed. The report will be in great demand throughout the whole country. N. H. W.

MONTHLY AUTHOR'S CATALOGUE

OF AMERICAN GEOLOGICAL LITERATURE ARRANGED ALPHABETICALLY.

ADAMS, E. P.

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CORRESPONDENCE.

CORRECTION. On page 29 of my paper "On the Apical End of the Siphuncle in some Canadian Endoceratidæ," etc., in the AMERICAN GEOLOGIST for January last, it is inadvertently stated that the genus (*Raphistoma*) is "not known to occur in rocks as old as the Calciferous; and "that the limestone at Kingston Mills is not older than the Chazy formation."

The first of these statements should read,—the genus is not known to occur in rocks older than the Calciferous; and the second—that the limestone at Kingston Mills is probably not older than the Calciferous formation. J. F. WHITEAVES.

Ottawa, April 25, 1905.

PERSONAL AND SCIENTIFIC NEWS.

DR. GEO. D. LAUDERBACK, of San Francisco, expects to work the coming summer on the geology of the Mount Diablo region east of San Francisco bay.

WILLIAM G. MATHER, president of the Cleveland-Cliffs Iron Company, delivered the Class Day Address May 5th at the Michigan College of Mines, Houghton.

DR. RALPH ARNOLD, of the U. S. Geological Survey, will spend the summer in investigations under the direction of Dr. Wm. H. Dall in the Tertiary of the Santa Monica mountains and the southern Mount Diablo range, California.

MINNESOTA ACADEMY OF SCIENCES. At the 274th meeting on May 9th Mr. Warren Upham presented a paper entitled

"Explorations of Verendrye and his sons in connection with the history and geography of northern Minnesota."

PROF. ALEXANDER N. WINCHELL of Butte, Mont., has been appointed to take charge of the state of Montana's exhibit at the Lewis & Clarke Exposition. He left Butte May 5th to go to Portland and direct the installation of the exhibit.

THE GEOLOGICAL DEPARTMENT OF COLBY COLLEGE, Waterville, Maine, has been abolished by the trustees of the college, the reason assigned for the action being a financial one. Prof. W. S. Bayley, who has been in charge of the department during the last sixteen years, will therefore sever his connection with the institution at the close of the present college year. (*Science.*)

THE SPRING MEETING OF THE NATIONAL ACADEMY OF SCIENCES was held in the Lecture Hall of the National Museum April 18th, 19th, and 20th. The programme was unusually brief, comprising only the following numbers:

I. The Mechanical Equivalent of Light, by Edward L. Nichols.

II. The Effects of Alcohol upon the Circulation, by H. C. Wood and Dan'l. M. Hoyt.

III. The Expedition of the U. S. Fish Commission Steamer "Albatross," in the Eastern Pacific, by Alexander Agassiz.

IV. Resequent Valleys, by Wm. M. Davis.

V. The Geographical Cycle in an Arid Climate, by Wm. M. Davis.

VI. A Catalogue of Spectroscopic Binary Stars, by W. W. Campbell.

VII. Discovery of the Sixth and Seventh Satellites of Jupiter and their Preliminary Orbits, by C. D. Perrine.

VIII. The Axis of Symmetry of the Ovarian Egg of the Oyster, by W. K. Brooks.

New members were elected as follows: J. C. Branner, Leland Stanford University, California; W. H. Holmes, Director Bureau of American Ethnology, Washington, D. C.; W. H. Howell, Dean of Medical Faculty, Johns Hopkins University, Baltimore, Md.; Arthur A. Noyes, Professor of Organic Chemistry, Massachusetts Institute of Technology, Boston, Mass.; Michael I. Pupin, Professor of Physics, Columbia University, New York City.

INTERCOLLEGIATE SUMMER FIELD COURSE in the Geology of the Appalachian Region. July-August, 1905. A geological field course of five weeks' duration, July 3rd to August 5th, 1905, will be given under the direction of several instructors, as detailed below, in selected localities of the Appalachian region, showing the undisturbed Mesozoic and Cenozoic strata and the littoral features of the Coastal Plain in Maryland, the

folded Paleozoic strata and the adjusted drainage system central Pennsylvania, the horizontal Paleozoic strata and Glacial phenomena of central New York, the ancient crys lines of the southern Adirondaks and the unconformably o lying strata, the metamorphic rocks and the Triassic basin western Connecticut.

This course is intended for teachers and students (1 only) who have already acquired some knowledge of g eral geology, including field-work. The fee for the cours $20, payable in advance to professor W. B. Clark, Johns H kins University, Baltimore, Md. Travelling and hotel penses will probably be about $100. The work of each w may be taken separately; the fee in this case will be $5 a we payable in advance to the instructor of the week. It may necessary to limit the number of students for the first we preference will be given to those who take the entire cou It is desired that members should enroll their names not la than June 15th with professor Clark for the entire course, with the instructor of the week they propose to attend. E member's outfit should include note-book, colored cray compass, clinometer, hammer, satchel, labels and small pa bags for specimens. U. S. topographic maps of the distr visited will be supplied at cost (about $1) to those who or them through professor Clark not later than June 1st.

It is probable that a field meeting of Section *E* (Geol and Geography) of the American Association for the vancement of Science will be arranged at Syracuse for J 21st and 22nd (the last two or three days of the Syrac week), when invited speakers will give some account of special features of the district and of their relations to sim features in other parts of the country. The field meetings the Section will probably follow the program indicated be for the last two days of the Syracuse week.

The circular issued gives a detailed itinerary of each we The instructors for the separate weeks are: professors W. Clark, W. M. Davis, T. C. Hopkins, H. P. Cushing, and [illegible]

THE

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THE FOSSIL TURTLES OF THE BRIDGER BASIN.

By O. P. HAY, New York.

The greater portion of the deposits known as the Bridger beds lie in the Bridger basin, a tract extending northward from the Uinta mountains to about latitude 42°, and east of the Wasatch range from about longitude 110°, 30 min., to about 109°, 30 min. The north and south extent of the basin is therefore about fifty miles, the east and west extent about sixty miles. The thickness of the deposits is given as from 2000 to 2500 feet. The strata are composed of clays, more or less arenaceous, interrupted beds of sandstone, and occasional thin layers of limestone. The argillaceous beds are usually yellowish, grayish, or greenish. The sandstone masses are commonly rusty brown. The stratification has a dip of from two to four degrees to the north.

Hitherto geologists have regarded these beds as lake deposits. Cope, Powell, Emmons, and King considered them to be such. There are large portions of this basin which the writer has not seen; but in 1903 he spent nearly two months in such typical portions of it as the Grizzly buttes and the region about the mouth of the Cottonwood creek. From observations made there the conclusion was reached that the deposits had been made almost wholly through river action. It is difficult to comprehend how such coarse materials as are often found in even the finer clay deposits could have been borne far out into the bed of a lake. Had the deposits been made in a lake there ought to be found, at each level, extensive tracts of very fine materials, representing the quiet central portions of the

body of water; but the presence of such beds has not been indicated.

To the writer it appears that this basin formed in Bridger times a nearly level country, through which perhaps many streams, which had their origin in the surrounding high lands, now the Uinta and Wasatch mountains, were flowing to some outlet. The basin had only a moderate slope, and was probably covered with vegetation, most probably a forest. The great mass of the materials was probably deposited during overflowing of the streams; and thus was produced the stratification everywhere observed. As might be expected, the character of the materials changes within moderate distances. Under such conditions of deposition, the coarser materials, pebbles and sand, would be dropped in the beds of the streams, the finer materials over the flood-grounds. Through the choking up of the channels by the accumulation of coarse debris and through other causes, these streams would often be forced to abandon their beds and cut new ones. The old channels would then become covered up; and at a later time, when erosion had done its work, many of these old channels would become exposed. One of the things which especially struck the writer in his peregrinations over and among the buttes of this region was what appeared to be the remnants of some of these old river-beds. Sometimes they appear as masses of sandstone many feet high, with the finer and more clayey layers coming up abruptly against their nearly perpendicular sides. Now and then one would be found emerging from the side of a butte and reappearing farther on in the side of a neighboring butte.

As the writer returned from Wyoming he was impressed by the conditions along the Platte river, a broad and shallow stream, nearly on a level with its flood-ground. This it must often overflow; and over this flood-ground it must wander about in ever changing channels. At that time the Kansas river had been overflowing its banks, and here and there, in the region about Lawrence, Kansas, old and abandoned river channels were again filled with water and appeared as temporary lakes far away from the present river. Should there occur at some future time in this re-

gion extensive erosion, so as to produce hills and valleys, some of these old channels would appear again as masses of sandstone enclosed by finer sediments.

The occurrence of abundant fossil remains of mammals and of reptiles in nearly all portions of the Bridger beds proves that there existed here no great and permanent lake. How many mammals or even of turtles are probably buried at a distance of ten or twenty miles from the present shores of lake Michigan? There can be little doubt that most of the animals whose remains we find in the Bridger beds lived near the spots where they were buried. They were such animals as would be found in a low wooded region. They were monkeys and bats, broad-footed uintatheres, horses with developed lateral toes, primitive tapirs and rhinoceroses, lizards, snakes, and crocodiles, river and marsh turtles. In the streams were gars and amias. The fauna was one of the most abundant and varied known in the history of the world. Already nearly two hundred species of mammals are known. The number of species is hardly surpassed by the Upper Eocene deposits of Europe or the Santa Cruz Miocene of South America. And constantly new and surprising things are coming to light.

In the present paper the writer proposes to discuss the chelonian portion of the Bridger fauna.

So far as appears, there is no other place in the world from which so many species of turtles have been obtained as from these Bridger beds. The number of well-founded species now appears to be thirty-nine. With few exceptions, they are forms that have evidently inhabited rivers and marshes. Many of them are closely related to the existing turtles of the rivers and ponds and marshes of the Mississippi valley. A few were probably terrestrial species which inhabited the surrounding high lands and were swept down to their burial places during times of high water. Individuals were evidently extremely abundant, and portions of their skeletons are to be seen almost everywhere. Complete shells are, of course, less common, but may be had by searching. Shells accompanied by limbs and skulls must be regarded as rare, but they too may be found.

Turtles from the Bridger beds have been described by

Dr. Leidy, Prof. Cope, and the writer. All three have visited the region and made collections. Dr. Leidy described altogether thirteen species, ten of which must be regarded as well founded. Two of these ten were described in 1869; three in 1870; four in 1871; and one in 1872. Of Cope's twenty-four nominal species eighteen appear to stand the test of critical study. Twelve of these eighteen were described in 1872; four in 1873; and two in 1884. Up to the present time the writer has described a single species. He has in hand materials for the description of about a dozen more.

Dr. Leidy and Prof. Cope were largely interested in the study of other groups of fossil vertebrates, and probably took no especial pains to secure good and abundant chelonian materials. A few of the shells described by them were quite complete, but many of the species were based on very fragmentary specimens.

In the year 1903, the writer, under the auspices of the Carnegie Institution, spent, in company with Mr. Walter Granger and Mr. Albert Thomson of the American Museum of Natural History, nearly two months in the region of the Grizzly buttes and along the lower portion of Cottonwood creek. While the others of the party were mostly engaged in collecting fossil mammals the writer gave especial attention to the securing of fossil turtles. Great care was taken to secure good materials and to get the whole of every specimen discovered. As a result of this work, there were obtained about 140 specimens. Some of these are indeed fragmentary; but many of them furnish fine shells, some of them large portions of the skeleton; and altogether about ten skulls were secured. Previously only one damaged skull had been brought from that region. Nearly the complete osteology of some species is now known which previously were represented by their shells only. In several cases, species which had been based on fragments of the shells are now represented by much more complete materials.

Three superfamilies of turtles are known to have had representatives living in this Bridger basin, the Amphi-

chelydia, the Cryptodira, and the Trionychoidea. No Pleurodira have yet been found.

The Amphichelydia are known in the Bridger beds by only the genus Baena. This genus was founded by Dr. Leidy, who described two species, *B. undata* and *B. arenosa*. Cope added *B. hebraica* and *B. ponderosa*, but the latter is based on unsatisfactory materials, and doubtfully belongs to the genus.

The new materials belonging to this genus collected in 1903 include several skulls, shoulder and pelvic girdles, limb bones, and cervical vertebrae. These specimens confirm the validity of Lydekker's group Amphichelydia, which was based especially on the shell of the English Pleurosternon, but regarded as including Baena. Pleurosternon is closely related to the Jurassic *Compsemys plicatula*. Baur thought that the latter species was the ancestor of Baena; but from the same quarries in the Jurassic that furnished Compsemys, the writer has described Probaena, a genus still more closely related to Baena. Probaena is also related to Platychelys of the Jurassic of Europe. In North America, Baena has now been traced back to the Judith River and the Belly River beds, therefore to the middle of the Upper Cretaceous. A study of the skeleton of Baena makes it certain that the group Amphichelydia furnished the ancestors of both the Pleurodira and the Cryptodira. The skull is almost wholly Cryptodiran, while the shell and the neck are Pleurodiran in structure.

Remains of the species of this genus are among the most common fossils in the Bridger beds; and since the shell is usually thick and the bones coössified the specimens are more likely to be well preserved than those of any other turtles. They were, without doubt, active swimmers, and able too to travel about on land. Their heads were short and broad, giving the animal a rather forbidding aspect. They were almost certainly addicted to the capture of living prey. Their habits and their appearance must have been much like those of our snapping turtle.

Coming to the Cryptodira, we consider first the genus Baptemys. Only one species, *B. wyomingensis* Leidy, has been described. Leidy's type did not furnish a complete

plastron. The expedition of 1903 obtained this and a portion of a skull. Furthermore, a good specimen of the species has been described by the writer from the Yale University Museum, which furnished a good plastron and most of the skull. The genus is to be assigned to the Dermatemydidae, now represented in Central America by three genera.

The family Anosteiridae is represented in the Bridger by the single genus Anosteira. It is not well known, only the shell having so far been discovered. The two species *A. ornata* Leidy and *A. radulina* Cope were of rather small size. They possessed beautifully sculptured shells. It is usually supposed that they were closely related to our modern snapping turtles, but a discovery of the rest of the skeleton might greatly modify this opinion. A large and imperfectly preserved species belonging to the Upper Eocene of England has been referred to this genus.

Of the Emydidae, the pond and river turtles, there are known eight Bridger species, all of which have been described by Leidy and Cope. In the Mississippi valley north of Tennessee, we find only about a dozen living species of Emydidae. The Bridger species have hitherto been placed in the genus Emys, but they certainly do not belong to this. They are more closely related to species of the genera Chrysemys and Clemmys. Notwithstanding the great number of species and individuals of this family which occur in the Bridger beds, only a portion of one skull has yet been found, and this is not associated with the remainder of the skeleton. This skull shows only a feeble development of the ridge on the masticatory surface of the upper jaw. It is not improbable that, when skulls shall have been found, these Bridger species of Emydidae will have to be placed in some new genus or genera. There can be no doubt that the habits of these Emydidae were essentially such as our modern river and pond turtles display. They haunted the borders of the streams, they captured living prey, and they betook themselves to the bottoms of the streams for protection from their enemies. Usually the shells are thick, a condition indicating probably in some cases a habitation in swift streams; in other cases possibly

a need for a greater specific gravity, in order to remain more easily at the bottom of the water; in other cases still, special protection against their enemies.

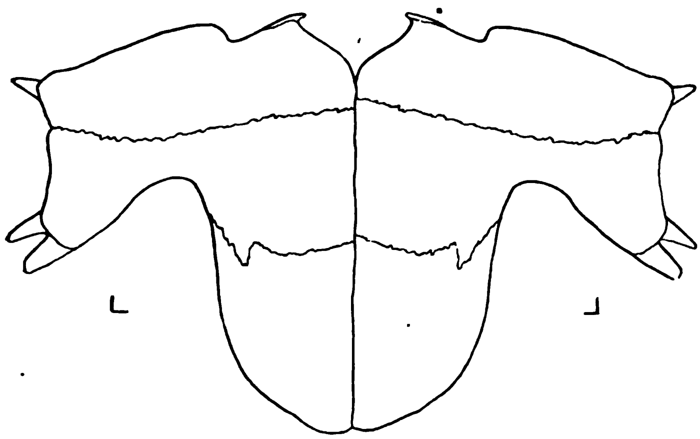
The Testudinidae, or true land tortoises, are represented in the Bridger beds by the genus Hadrianus. Three species have been recognized; but one of these, *Hadrianus allabiatus* Cope, is based on very doubtful materials; while Cope's *H. octonarius* is not to be distinguished from Leidy's *H. corsoni.* This species reached a length of nearly three feet. No skull of the genus has yet been found, but there can be no doubt that it was a true land tortoise, such portions of the internal skeleton as have been discovered agreeing well with those of Testudo. The shell had not yet reached that high degree of differentiation which characterizes that of our modern members of the genus Testudo, but it was on the way. This animal probably lived on the dry lands bordering the Bridger basin.

The superfamily Trionychoidea, or soft-shelled turtles, was abundantly represented during Bridger times, somewhat more than one-half of the species found in southwestern Wyoming belonging here. The writer is acquainted with twenty-two species. According to the British Museum Catalogue of Chelonians there are at present living in the whole world only twenty-six species. Only six species now inhabit the United States. The Bridger rivers and brooks must have swarmed with these creatures. Some of them attained a large size, equalling or nearly so some of the Asiatic species, one of which, *Amyda triunguis* (Forsk.) has the dorsal disk 31 inches long.

Of the Trionychoidea the writer recognizes two families, the Trionychidæ and the Plastomenidæ. The type of the latter family is the genus Plastomenus Cope. That which distinguishes this genus from all the genera of the Trionychidæ is the completeness of the plastron. In the members of the latter family there are always fontanelles between the lateral halves of the plastron, as well as others between the carapace and the outer ends of the hyoplastron and hypoplastron. In a few species these may become nearly closed in extreme old age. The species presenting the most nearly complete plastron is *Cycloderma aubryi,*

figured by Siebenrock (Sitzber. Akad. Wissensch. Wien, xci, 1902, p. 836). No specimen of Plastomenus has yet furnished the epiplastra; but in the American Museum of Natural History are several specimens of *P. thomasii* which present the hyoplastra, the hypoplastra, and the xiphiplastra; while one specimen of *P. oedemius* has furnished the entoplastron. These materials show that nearly as far forward as the entoplastron, the lateral halves of the plastron were as closely joined as in the Emydidae. The antero-interior angles of the hyoplastra are truncated, so as to form a median notch, but this is nearly filled up by the broad entoplastron. The fontanelles at the outer ends of the hyo-hyoplastral bones too are nearly closed. The carapacial disk likewise is at an early age filled out nearly to the ends of the ribs. A well-preserved skull of *Plastomenus thomasii* was found in 1903, but it does not appear to be essentially different from that of the Trionychidæ. The palate has not yet, however, been exposed to view. The skull is long and pointed, as in *Platypeltis mutica*. The limbs are as yet unknown.

Of Plastomenus Cope had only fragmentary materials when he described the genus; and, while he recognized that the plastron was more complete than in the Trionychidæ, he was unable to define well the genus. Moreover, he included in the genus some species which belong elsewhere. First from a specimen collected for Prof. Cope in the Bridger beds of the Rattlesnake range, Wyoming, but never studied by him, was the writer able to understand the real structure of the plastron and carapace. A figure of the plastron of this specimen is here presented.



The Trionychidæ form an important part of the existing faunas of North America, Africa, and Asia. The division of the family into genera has proved to be a difficult undertaking. Most of the living, as well as of the fossil species, have hitherto been referred to the genus Trionyx. The genera have been discussed by the writer in the Proceedings of the American Philosophical Society, vol. xlii, 1903, pp. 268-274. Dr. Stejneger (Science, xvi, 1905, p. 228) has since shown that Amyda Oken antedates Aspidonectes Wagler. The new genus Aspideretes is proposed by the present writer in the article cited for such Trionychidæ as possess eight pairs of costal plates and a preneural, a plate between the nuchal and the first neural. To this genus are referred three Bridger species. One of these was described by Dr. Leidy under the name *Trionyx guttatus* His material consisted of only a portion of the rear of the carapace. The expedition of 1903 secured portions of three individuals. These furnish most of the plastron and of the carapace, the pelvis, and portions of the femora. Unfortunately, in all the specimens the region in front of the first neural is damaged, so that the existence of the preneural is yet doubtful, but probable. Even in aged individuals there was a pair of fontanelles, one on each side of the midline, behind the nuchal. Two other species of the genus were discovered in 1903, both represented by fine carapaces.

The genus Amyda Oken embraces species which have

eight pairs of costal plates and no preneural. Many of the living species belong to this genus. *A. uintaensis* (Leidy) *A. radulus* (Cope), *A. scutumantiquum* (Cope), and probably *A. concentricus* (Cope), all belong here. All were described under the genus Trionyx. *A. radulus* was originally described by Cope from the Wasatch of New Mexico, but he referred to the species also a specimen from the Bridger of Wyoming. This is now in the American Museum of Natural History. The type from New Mexico appears to be lost. The American Museum possesses two carapaces, one nearly complete, collected near Opal, Wyoming, which certainly belong to the same species as Cope's Wyoming individual, identified as *A. radulus;* but whether or not the Wasatch specimens are the same remains doubtful. The Opal specimens come from the base of the Bridger beds; and it is possible that the species continued through the Wasatch and Green River epochs to the Bridger.

To the genus Amyda is referred with some doubt a fine skull which the writer discovered near the mouth of Cottonwood creek, and to which the name *A. tritor* has been given (Science, xix, 1904, p. 254). As the shell was not present, the skull may belong to some other genus and possibly to some of the already described species. It has a length of nearly six and one-half inches and resembles closely the skull of *Platypeltis ferox* of our southern states.

The genus Platypeltis is characterized by the reduction of its costal plates to seven pairs. At the most, there may be vestiges of the eighth costals. The young have a smooth or finely granulate skin. The living species of North America belong to this genus. Four species are known from the Bridger. One of these is *P. heteroglyptus*, described as *Trionyx heteroglyptus* by Cope from the hinder half of the carapace. The nuchal was present with Cope's specimen, but not known to him. Another and complete carapace was collected in 1903. In Cope's type the eighth costals were wholly undeveloped; in the new specimen these are present, each lying in a notch in the posterior border of the corresponding seventh costal. *Platypeltis trionychoides* (Cope) was described from fragmentary materials as a Plastomenus. One nearly complete

carapace and two plastra, one nearly complete, show now that the species is a Platypeltis. *Platypeltis serialis* (Cope) was also originally described as a Plastomenus, from the Wasatch beds of New Mexico. The American Museum party of 1903 collected a carapace and large portions of two plastra; and Mr. Paul Miller, of the American Museum, collected in 1904, a complete carapace of a species which it seems now necessary to refer to Cope's Wasatch species. It is not at all unlikely that better Wasatch materials will prove the Bridger form distinct. In the complete carapace referred to, the costals of the eighth pair lie in notches in the costals of the seventh pair and not in contact with each other.

Axestemys byssinus was set apart by Cope in a separate genus, Axestus, preoccupied; but the materials representing the only species are scanty and the characters doubtful. The plastron is devoid of pits and ridges. Cope made much of a clothlike network of the superficial bony fibers; but this is found in all trionychids.

Most of the species of Bridger turtles which have been described have come from the region within a few miles of Ft. Bridger, the Grizzly buttes, Cottonwood creek, and Church buttes. Of some of the species described by Cope and Leidy exact localities are not given. Not enough collecting has been done in other localities and levels to enable us to determine with certainty whether the species changed rapidly or endured throughout the whole Bridger epoch. Further collecting ought to be done about Opal, in the lowest division of the Bridger and along Henry's fork, where the higher beds are exposed.

It is now in order to determine if possible the origin of the various parts of the Bridger turtle fauna.

Considering first of all that important element constituted by the genus Baena, we cannot doubt that it descended from ancestors which inhabited the same region during the Upper Jurassic, and which are represented by *Compsemys plicatula* and *Probaena sculpta*, These species were closely related to Pleurosternon and Platychelys of Europe and were a part of that fauna which had at that time extended itself over the Northern Hemisphere. The

genus Baena has now been traced back through the
satch, the Puerco, and the Laramine, to the Judith Rivei
Belly River beds of the middle of the Upper Cretaceous
we may confidently expect to find in some freshwate
posits of the Lower Cretaceous other forms connecting
genus with Probaena. It is interesting to note the fact
while the Amphichelydia died out in Europe during
Lower Cretaceous, they persisted in North America
the Uinta. Furthermore, that it held its ground long
one of the great superfamilies to which it had given oı
the Pleurodira, had been driven from the continent; fo
know of no members of the latter group in our coı
after the Cretaceous.

Taking up next the Trionychoidea, the soft-shells
must believe that those of the family Trionychidæ
descended from forms which lived in North America dı
the Upper Cretaceous. Several species occur abund
in the Laramine and in the Judith River and Belly I
beds of Montana and British America. Of these Cretac
species, all that are sufficiently well known belong tc
genus Aspideretes, those with the preneural, and the w
believes that this is the most primitive known genus o
family. So far as we know, no important changes
taken place in the structure of these animals since the
dle of the Upper Cretaceous. *Aspideretes beecheri* is b
on a specimen at Yale from the Laramie of Converse c
ty, Wyoming. Nearly the whole of the skeleton, excep
head is present. It differs little from others of the fa
living to-day. Apparently this species comes to us
the still older Judith River beds. We cannot, there
doubt that the family had had a long previous history;
it is to be expected that more primitive trionychids
yet be found in some of the freshwater deposits oi
Lower Cretaceous, in company with remains of the
representatives of Baena. Ameghino has reported C
ceous trionychids from South America. The living T
nychidæ appear to love flowing waters; and the same l
appears to have possessed the other known forms.
may therefore expect to find their remains only in
deposits of the Lower Cretaceous.

Professor Cope referred to the genus Plastomenus some fragmentary materials from the Cretaceous, but there is no certainty about the correctness of the conclusion. Nevertheless, we must suppose that there were Cretaceous Plastomenidæ; and the writer believes that it is from this family that the Trionychidæ have been derived. The plastomenids are nearer to the Cryptodira, and have through degeneration, lost their peripheral bones. Through still further degeneration, in adaptation to aquatic life, the carapace and especially the plastron of the Trionychidæ have become still further reduced. The Plastomenidæ possess a preneural bone, and from them the genus Aspideretes retained the bone.

Of the Anosteiridæ we know too little to permit any attempts at ascertaining their history.

As regards the Dermatemydidæ, represented by Baptemys, it seems to the writer that we are justified in connecting the family with Adocus, which is a common genus in the Upper Cretaceous of New Jersey. One species of the genus occurs in the Puerco beds of New Mexico. Professor Cope's *Chelydra crassa* (*Hoplochelys crassa*) of the Puerco appears to be a dermatemyd.

Of the Emydidæ no species has been described from any formation older than the Wasatch; but from this Cope has described on good materials a number of species. At almost the same time, species appeared in the London Clay of England, and these have been referred to the existing genus Chrysemys. No older true emyd has been described from any country; but in the American Museum of Natural History there is a specimen the relationships of which appear to be with the Emydidæ. It comes from the Judith River beds of Montana, and was collected many years ago for Cope. The plastron is broad and appears to be constructed as in the Emydidæ. If further investigation and discovery shall confirm this reference of the species to the Emydidæ, our country may for awhile claim the origin of the family.

As already stated, the Testudinidæ, or true land tortoises, are represented in the Bridger beds by the genus Hadrianus, which affords at least one large species. The

writer has had the opportunity of describing a fine large species of the genus, *Hadrianus majusculus*, from the still older Wasatch beds. So far as he knows, nothing older of the family has been described. Dollo has reported a Testudo from the Lower Eocene of Belgium, but it appears not yet to have been described. Whether it is a true Testudo or a Hadrianus remains to be seen. The ancestry of the family evidently goes back into the Cretaceous, and its fatherland we know not.

It may be instructive to consider what elements are conspicuously missing from the Bridger turtle fauna. There are no marine forms; no Thalassochelys, no Argillochelys, no Lytoloma. We must infer from this and other facts, that the basin was well shut off from the sea. There are likewise no Pleurodira. It is more surprising that there are no undoubted Chelydridæ; for Anosteira may better be retained in a family of its own. Chelydra has the marks of an ancient form, and we might suppose that the conditions furnished in the Bridger basin were eminently favorable for its existence; but Chelydra first appears in the Upper Oligocene of Europe. It is not known that the genus appears in America before the Pleistocene, for *Chelydra crassa* Cope, of the Puerco, must be regarded as a dermatemyd, to be called *Hoplochelys crassa*. There are no Cinosternidæ. Among the Emydidæ, there is no true Emys, with hinged plastron; nor any Terrapene, box-tortoise, with a more perfectly hinged plastron. The emyds present probably belong neither to Chrysemys nor to Clemmys, although closely related to both.

Professor Osborn (Ann. N. Y. Acad. Sci., xiii, 1900, pp. 19, 46) synchronizes the Bridger beds with the Bartonian and the lower portion of the Ligurian. So far as the writer knows, the Barton has furnished no turtles. On the contrary, the Ligurian, as represented in England and France, has yielded numerous turtles. These are mostly Trionychidæ, which have been described under the name Trionyx, but would be included by the writer under Amyda. There are also Emydidæ, a supposed Anosteira, and a supposed dermatemyd, *Trachyaspis hantonensis*. There are no Plastomenidæ, no Testudinidæ, and no Amphichelydia. The

chelonian fauna is therefore poorer in all respects than that of the Bridger beds, but much like the latter as far as it goes.

A few words may be added regarding the relations of the Bridger turtles to those of North America to-day. From materials in the American Museum of Natural History it is known that the genus Baena continued on until the Uinta. After this nothing is known of it. It is certain that the genus Baptemys became extinct, leaving no descendants living to-day. No Bridger dermatemyds are yet known which gave rise to the species living now in Central America; but such probably existed; and a member of the family has recently been discovered in the White River beds of South Dakota. Anosteira probably died out during or soon after the Bridger epoch. That some of the Emydidæ of the Bridger beds were the direct ancestors of the numerous species of Chrysemys now inhabiting North America is very probable. Clemmys is represented in North America by four species and in Europe and Asia by an equal number. It therefore becomes a question which continent supplied the other. North America at present has the best claim on the genus, for the writer (Bull. Dept. Geol. Univ. Cal. iii, p. 237) has described one species from the Pliocene of Oregon and another from the Upper Miocene.

Emys, as at present recognized, is represented by a single species in North America and by one quite similar in Europe and Asia. It is not at all improbable that the genus has come to us from Asia, and that from it there has been developed here the various species of Terrapene, or box-tortoises.

The genus Hadrianus is known in North America from the Wasatch into the Uinta. As remarked by Lydekker, some of the early European species referred to Testudo may belong to Hadrianus. There seems to be no reason why the genus should not be regarded as having furnished the ancestors of the various species of Testudo which spread themselves over the world during Tertiary times. In North America genuine species of Testudo appeared in the lowest White River beds and continued on into the Pleistocene. On the other hand, it may be doubted whether

the land tortoises now living in North America have descended from Hadrianus. They have been separated under the name Xerobates, on account of the symphysial ridge of the upper jaw. During the White River and John Day epochs there existed a few species of the genus Stylemys. An imperfect skull, referred to *S. nebrascensis*, nwo belonging to Princeton University, displays the same peculiar structure. There are also various resemblances between the shells of the living and the extinct forms; so that a real relationship is suggested.

ON THE LANSING MAN.*

By Prof. S. W. WILLISTON, Chicago, Ill.

In the latter part of March of the present year a brief newspaper note announced the discovery of a human skull and other bones in a deep excavation made by Mr. Martin Concannon, for the purpose of storing vegetables and dairy products, in the vicinity of Lansing, Kansas. The excavation had been begun more than a year previously, but was not completed until in February, 1902, at which time the skeleton was discovered by the two sons, Messrs. Michael T. and Joseph H. Concannon, near its extremity, or about sixty-nine feet from the entrance. Occasional bones, probably of other animals, had been discovered during the progress of the work, and not a great deal of interest was excited by the exhumation of the human bones. They were, however, for the most part, laid aside, though many fragments of small bones had been cast out with the excavated material. It was not until the latter part of March following that Mr. Michael Concannon showed a part of the mandible to a newspaper reporter, who published the first brief notice of the discovery. This notice attracted the attention of Mr. M. C. Long, of Kansas City, who immediately visited the site of the discovery in company with Mr. Butts, a civil engineer, of Kansas City, who secured such of the bones as

* From the Proceedings of the International Congress of Americanists, held in the American Museum of Natural History, New York, October 20 to 25, 1902. Thirteenth Session (pages 85-89). This volume was much delayed in publication, until March, 1905.

had been preserved. Immediately thereafter there was widely published a newspaper account of the discovery in some detail, ascribing the bones to the glacial age.

I had planned to visit the locality when the first notice was published, but, learning from Mr. Concannon that the bones had been taken to Kansas City, I did not make an examination of the place until the nineteenth of July, in Mr. Long's company and by his invitation. The results of my observations and my conclusions were published in *Science* foı August 1st. On August 9th a further and more careful study of the site and adjacent region was made by Professor N. H. Winchell, Mr. Warren Upham, Professor E. Haworth, Mr. Long and myself, an account of which was published by Mr. Upham in *Science* for August 21st and in the *American Geologist* for September, together with additional notes by Professor Winchell. On the 19th of September a still further examination was made by Professor T. C. Chamberlin, Professor R. D. Salisbury, Professor W. H. Holmes, Dr. G. A. Dorsey, Professor E. Haworth and Mr. Long. The conclusions reached by these observers do not agree wholly with those of the previous observers, though, I believe, there is no contention as to the authenticity of the discovery or of the fluviatile character of the deposits in which the bones were found.

The bones of the skeleton, when examined, had attached to them considerable masses of the characteristic matrix, in some places of almost stony hardness. Suffice it to say that the evidence of the genuineness of the bones is apparently beyond dispute. All the scientific men who have investigated the subject conclude, I believe, that the bones were actually found by the Concannons where and under the circumstances they describe. Fortunately, hence, whatever conclusions are reached regarding the bones by competent students, there will be no question as to the authenticity of the discovery.

The skeleton was found irregularly disposed, according to the testimony of the discoverers. This statement is, in part at least, borne out by the evidence presented by the bones themselves. The right acetabulum has an indurated matrix within it showing the impression of the head of the

femur. Some fragments of the bone still attached to this matrix show conclusively that the femur when found was almost directly reversed in position, lying parallel with the trunk. The left femur had been removed from its socket, but fragments of it attached to the horizontal ramus of the pubis show that it must have been lying more or less obliquely as regards the pelvis. Further details regarding the skeleton I leave for the abler pen of Dr. Hrdlicka. Of immediate interest, however, is the fact that a single left maxilla, belonging to a second skeleton, was discovered by the young men ten and one-half feet distant from the other, lying almost upon the limestone floor of the tunnel at its extreme edge. This maxilla is that of a child, as is shown by its smaller size, the presence of two deciduous molars, and a non-erupted canine tooth. In former notices of the discovery by both Mr. Upham and myself this maxilla was confounded with a half of the mandible of the other skeleton, owing to the imperfect description of the bones by the young men.

The bones, sixty-nine or seventy feet from the entrance of the tunnel, were at a depth of nineteen or twenty feet from the present surface. It is needless to say that the roof of the tunnel shows no evidence whatever of previous disturbance. The walls and gently arched roof of the tunnel have no support other than that afforded by the coherency of the material, and any previous excavation would certainly have left conspicuous and ineffaceable evidences of disturbance. This I mention because various newspaper writers, with more zeal than wisdom, have explained the occurrence of the bones as those of convicts from the state penitentiary, buried at this place. All such stories are absurd in the extreme.

The limestone floor of the tunnel is covered by from two to four feet of ancient débris of limestone fragments and shales, more or less rounded and of moderate size, which had evidently rolled or slid down from the adjacent hillside. Lying in the upper part, or more probably upon this débris, and enveloped in the silicious loess, was found the skeleton, perhaps two feet above the limestone floor. Neither among this coarse débris, nor elsewhere in the

walls of the excavation, could be found any foreign pebbles or other material. Above the débris and partly intermingled with it, the walls are composed of siliçious, calcareous, grayish yellowish loess, of river origin. Interspersed through it are occasional pebbles of water-worn limestone, and from the roof were obtained quantities of rounded flinty and calcareous pebbles, a quarter to a half inch in diameter, and clearly water-worn. Gasteropods of four or five species were obtained from the walls of the excavation, and from the edge of the roof, nearly seven feet from the floor, Mr. Long and I dug a complete cast of a *Unio*, showing clearly the markings of both valves.

The surface of the ground immediately above the site of the bones slopes upward toward the east, that is, toward the river valley, for less than one hundred feet to the summit of a small terrace, fifteen feet higher up, overlooking the river valley, and upon which Mr. Concannon's house is situated. It is certain—I use the word with scarcely any hesitation—that originally at least thirty-five feet of river loess had covered the skeleton. Since 1844 the highest water of the Missouri river was in 1881. At that time the water reached, according to Mr. Concannon who has lived at the place for thirty-five years, to within twelve or thirteen feet of the horizon of the bones. The high-water mark then was twenty-five feet above the low-water mark, making altogther seventy-two or seventy-three feet as the elevation of the loess terrace above the river, and fifty-seven or fifty-eight feet as that of the present surface over the bones.

I am aware that some of the geologists, who have recently examined the tunnel, while admitting that the material in which the bones were found is of river deposition, believe that most of the material above them is of wind construction. I regret to say that I must differ decidedly from this opinion. Water-worn pebbles in quantities several inches in thickness and thirty or more feet in extent, according to Mr. Butts, and complete shells of clams, are not what we would expect to find in æolian deposits!

Perhaps a foot above the horizon of the bones there is a very distinct stratum of darker, more argillaceous material, from half an inch to three inches in thickness, traceable

nearly the whole length of the tunnel with an inclination toward the mouth of the excavation of about seven inches in the seventy feet. In the upper part of the tunnel the homogeneous material shows only slight stratification marks—still they are to be seen and are horizontal. I have collected many fossils from real æolian deposits of the plains, but never under such conditions as are found here. Upon the surface of the hillside above the excavation are at present to be found quartzite boulders and pebbles. The limestone hills sloping up from the terrace above the excavation to a height of a hundred and fifty feet have abundant evidence of glacial pebbles and boulders. Is it not reasonable to suppose that in past times the débris and fragments sliding and falling down this hillside would have left evidence of intercalated material in the mud deposits? There are no such evidences in the walls of the tunnel.

As to the age of the deposits in which the bones were found I can offer no decided opinion except that they are of Pleistocene time, contemporary with the recently extinct Equus fauna. Professors Winchell and Upham believe them to be of the Iowan or earlier stage of the Glacial period. They may be correct, but I am not sufficiently familiar with glaciological phenomena to vouchsafe an opinion. I am only confident that the skeleton dates from Pleistocene times—and is old.

AGE OF THE ST. CROIX DALLES.

By WARREN UPHAM, St. Paul, Minn.

The most beautiful gem of scenery in the states of Minnesota and Wisconsin is the Upper Dalles of the St. Croix river, which forms a part of the boundary between these states. By legislative acts of each state, the land on both sides of the river, adjoining this picturesque rock gorge, has been made an Interstate Park, for public enjoyment and instruction, similar to the International Park at Niagara Falls. From the "Twin Cities" of St. Paul and Minneapolis, and from a large surrounding region of both Minnesota and Wisconsin, many picnic excursions come to the St. Croix Dalles; and many tourists, especially geologists and naturalists, are attracted thither, to see the beautiful and grand scenery of the gorge, and its wonderful waterworn potholes, such as in Germany and Scandinavia are called giants' kettles.

Therefore much attention has been given to the geology of the vicinity of the Dalles, by Prof. N. H. Winchell and the present writer, as his assistant, on the Geological Survey of Minnesota;* by Dr. C. P. Berkey, Mr. A. H. Elftman, and the writer, in later papers, coming to the study of this area from its Minnesota side;† by Prof. T. C. Chamberlin and his assistants on the Geological Survey of Wisconsin;‡ and most recently by his son, Mr. Rollin T. Chamberlin, who last year spent a month in examination of the Dalles region.§

The last author has well described and mapped the deploying currents and recessional moraines of the Lake Superior lobe of the ice-sheet, developed during the Wis-

* Geology of Minnesota, vol. i, 1884, pp. 126-7; vol. ii, 1888, pp. 399-425, with a map of Chisago, Isanti, and Anoka counties.

† Charles P. Berkey, Geology of the St. Croix Dalles, AM. GEOLOGIST, vol. xx, pp. 345-383, with maps and sections, Dec., 1897; and vol. xxi, pp. 139-155, and 270-294, with maps and plates, March and May, 1898.

A. H. Elftman, The St. Croix River Valley, AM. GEOLOGIST, vol xxii, pp. 58-61, July, 1898.

Warren Upham, Pleistocene Ice and River Erosion in the St. Croix Valley of Minnesota and Wisconsin, Bulletin, Geol. Society of America, vol. xii, pp. 13-24, Nov., 1900; Giants' Kettles eroded by Moulin Torrents, Bulletin G. S. A., vol. xii, pp. 25-44, with a map of the Upper Dalles, Dec., 1900.

‡ Geology of Wisconsin, vol. i, 1883, pp. 261-300, including a map of the Minnesota, Superior, Chippewa, Green Bay, and Michigan lobes of the ice sheet, the Driftless Area, etc.; vol. iii, 1880, pp. 363-428; and vol. iv, 1882, pp. 99-159.

§ The Glacial Features of the St. Croix Dalles Region, Journal of Geology, vol. xiii, pp. 238-256, with three maps, April-May, 1905.

consin stage of waning glaciation, and also the courses of movement and the terminal moraine of a far eastwardly projecting outflow from the great Keèwatin ice-lobe of the northwest. The former brought red drift, colored by the peroxide of iron from the red sandstones and shales of the Lake Superior basin, and destitute of limestone fragments; while the latter, an ice invasion from the Cretaceous, Silurian, and Cambrian region of the Red river valley and Manitoba, brought gray drift, with abundant limestone boulders, pebbles, and finely comminuted rock flour. In the region of the St. Croix Dalles, the red Lake Superior drift forms the surface on the Wisconsin side, and reaches far westward under the gray drift, which overspreads the surface in Minnesota and reaches sparingly east across the St. Croix river, as carefully traced by Mr. Chamberlin, to a distance of about one to three miles into Wisconsin for several miles north and south of the Dalles.

In several details I see reasons to question some of Mr. Chamberlin's conclusions: (1) where he refers the gray drift to a later time than the red drift, supposing that the Lake Superior ice had melted off from this vicinity before the Keewatin ice advanced here; (2) in his regarding the preglacial course of the St. Croix river as perhaps a few miles east of the Dalles, passing into the Apple river valley, and thence to the lower St. Croix valley; and (3) in his reference of the erosion of the Dalles gorge to the work of the river since the final retreat of the ice-sheet. All these questions are related to studies and conclusions presented five years ago in my two papers before cited in the Bulletin of the Geological Society of America, which appear not to have been considered by Mr. Chamberlin in his recent work. Therefore portions of those papers are used again in the following discussion of these several points, all bearing on the age of this river gorge.

1. The Lake Superior and Keewatin ice lobes seem to me to have been contemporaneous, being confluent along an uneven and wavering line, where their glacial currents met, or where one overrode the other, as at these Dalles, and along a course trending with much irregularity and minor lobation in a general northwesterly and northerly

direction thence through central and northern Minnesota. This principal interlobate line or belt was similar to those lying in succession between the Superior, Chippewa, Green Bay, Michigan, and more eastern lobes of the very broad Laurentide part of the continental glacier, as mapped by Prof. T. C. Chamberlin.*

Why the Keewatin glacial currents were finally stronger than those from the Lake Superior region, pushing them back or overriding a part of that ice lobe, I have explained by the climatic conditions attendant on the progressive melting of the ice borders mainly from southwest to northeast and from west to east, enabling the gray drift to spread over the red drift on the east side of the Keewatin lobe, in eastern Minnesota, from St. Paul northeast and north to Taylor's Falls and Rush City.†

2. It was suggested by Moses Strong, of the Wisconsin Geological Survey, that the St. Croix, or more probably a branch of it, may formerly have flowed through the ravine, about three-fourths of a mile east of the Upper Dalles, in which the railroad runs south from the station of St. Croix Falls, that channel being abandoned when the present channel in the Dalles became deep enough, through erosion, to carry all the water.‡

Berkey and Elftman, in their papers before cited, argue that the preglacial upper part of the St. Croix passed west of the Dalles, the former regarding it as probably tributary southwestward to the Mississippi, and the latter tracing its course in coincidence with the Sunrise river and Chisago lake to rejoin the present St. Croix valley farther south.

Mr. Rollin T. Chamberlin thinks that the preglacial St. Croix river, flowing past the site of the Dalles in the channel mentioned by Strong, may have continued past Dresser Junction, and along Horse creek valley to the Apple river, which lower down empties into the present St. Croix.

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* Geology of Wisconsin, vol. i, as before cited; U. S. Geol. Survey, Third Annual Report, for 1881-82, pl. xxviii, and Seventh Annual Report, for 1885-6, pl. viii.

† Changes in Currents of the Ice of the Last Glacial Epoch in Eastern Minnesota, Proceedings of the Am. Assoc. for Adv. of Science, vol. xxxii, for 1883, pp. 231-234; Geology of Minnesota, vol. ii, 1888, pp. 254-256, 409-417, 463, 603-605.

‡ Geology of Wisconsin, vol. iii, 1880, p. 416.

My consideration of this question, in the first of the two papers cited as published in 1900, is stated as follows:

The very long Tertiary era, preceding the Ice age, had permitted the larger streams of Minnesota and Wisconsin to erode deep and wide, well matured valleys, free from waterfalls or strong rapids, and having no narrow, rock-walled gorges, like the Dalles of the St. Croix. But in the northern drift-covered part of the United States, and throughout Canada, the rivers, on their again coming into existence when the ice of the Glacial period melted away, found themselves in many places turned aside from their preglacial courses by the drift deposits and by the movements of continental uplift and subsidence that were associated with the Ice age. In some cases formerly independent streams were thus united to make a single larger river system; and often a river was turned out of its old drift-filled valley for a comparatively short distance, as a few miles, being there compelled to cut a new gorge in the bed-rocks.

One or the other of these results of the Glacial period has been well ascertained as the fortune of so many rivers in the great drift-covered region that the occurrence of the two short, grandly picturesque rock gorges, or canons, known as the Upper and Lower Dalles of the St. Croix, so named by the French voyageurs in allusion to their inclosing walls of rock, strongly suggests that there the stream is now flowing in a course which it has cut during and since the Ice age. No closely adjacent belt, however, seems to be probably identifiable as a drift-filled preglacial valley. Therefore, from my studies, for the Minnesota Geological Survey, of the country extending many miles westward from the St. Croix, I conclude that in preglacial times this river was represented by two quite independent rivers, each flowing into the Mississippi.

The greater part of the St. Croix drainage basin, including all above the rapids, six miles long, which end at St. Croix Falls and Taylor's Falls, I think to have belonged before the Ice age to a river flowing south and southwest from the principal elbow of the present St. Croix, taking approximately the course of the Sunrise river, which, however, now runs northward, and traversing Anoka county to a junction with the Mississippi somewhere between Anoka and Minneapolis. Thence, as Prof. N. H. Winchell has shown, the preglacial course of the Mississippi probably passed southeastward.*

* * * *

A broad, low belt of sand and gravel plains stretches across the distance of nearly 40 miles from the St. Croix to the Mississippi at Anoka, nowhere having a greater hight than 150 feet above

* An Approximate Interglacial Chronometer, AM. GEOLOGIST, vol. x pp. 69-80, with sections and a map, August, 1892. On this map the probable preglacial and interglacial channels of the Mississippi in the vicinity of Minneapolis and St. Paul are delineated, differing much from its present course.

the elbow of the St. Croix and the mouth of the Sunrise river. On the east, between that low tract and the St. Croix valley, a belt of rolling and hilly glacial drift or till, underlain in part by the bed-rocks at a greater altitude than the sand and gravel area westward, divides it from this valley. * * * *

About a sixth part of the St. Croix basin, lying east and south of Taylor's Falls, appears to have been drained during the Tertiary era by a stream coinciding nearly with the Apple river and the lower thirty miles of the St. Croix river. The large basin and river first described may be called the preglacial St. Croix, and the lower small stream may be distinguished as the enlarged preglacial Apple river.

These Tertiary drainage areas, which by the vicissitudes of the Ice age became united into one stream, the present St. Croix, I think to have been divided, up to the time of the ice accumulation in the Glacial period, by a watershed of the very old trappean and Cambrian rocks, extending from northeast to southwest across the sites of the town of St. Croix Falls and Taylor's Falls.

3. Berkey ascribes the erosion of the river gorge at the Dalles to Late Glacial and Postglacial time, and thinks that the larger part of the erosion was accomplished at the immediate close of the Glacial period, during the time the river served as the overflow channel for the West Superior glacial lakes.

Nearly the same view is presented also by Mr. Chamberlin, who, reasoning from the hights of the sand and gravel terraces, modified drift deposits, in this valley at Taylor's Falls and northward, concludes that the cutting of the deep, but short, gorge in the Keweenawan has all been accomplished by the St. Croix since the retreat of the last ice-sheet.

Again I may most clearly and definitely give my reasons for a different view by quoting from the same paper, Pleistocene Ice and River Erosion in the St. Croix Valley of Minnesota and Wisconsin, read before the Geological Society of America five years ago.

In the Twenty-third Annual Report of the Minnesota Geological Survey, for the year 1894, I have stated (on pages 188-190) the evidence that the recession of the ice-sheet during the Buchanan interglacial stage, which succeeded its Kansan stage of maximum area west of the Mississippi, extended northward beyond the site of Barnesville, Minnesota, on the southern part of the great valley

plain of the Red river of the North. Probably at that time the ice had been melted away from nearly or quite all of the southern half of Minnesota. That the retreat of the ice-sheet had uncovered the southern third of the St. Croix basin is shown, in Nessel township, Chisago county, Minnesota, near Rush City, by an interglacial land surface, with wood and peaty matter upon a deposit of modified drift that was laid down during the previous retreat of the ice.* Above the wood and peat of this place, and above an extensive plain of the Buchanan modified drift reaching thence several miles eastward, a somewhat uniform mantle of till, 10 to 20 feet deep, was spread during the ensuing Illinoian and Iowan glacial readvance.

We thus know that the district including the Dalles and extending northward at least to Rush City was uncovered from the ice-sheet during the Buchanan stage of the Glacial period. Later the increasing snowfall again permitted nearly all of this basin to be enveloped by the ice of the Illinoian and Iowan stages, reaching on the St. Croix river southeasterly to the conspicuous moraine belts which pass from St. Paul and Minneapolis northeastward to the northern half of lake St. Croix and through the southeastern part of Chisago county, continuing thence onward in Wisconsin.

Terraces of sand and gravel, which are found in the St. Croix valley 4 to 10 miles north of Taylor's Falls, mostly having a hight of about 90 feet above the river, are remnants of valley drift deposited during the Wisconsin stage of the final departure of the ice-sheet. These gravel deposits, continuous as one expanse of modified drift from the jack pine barrens of northwestern Wisconsin, bear testimony that a part of the floods from the dissolving ice then passed southward along the present St. Croix, and that the erosion of the valley in the vicinity of the Dalles had been mainly accomplished previous to the Wisconsin stage. We are led, therefore, to the conclusion that much channeling of the valley here, enlarging it along all its course from the Dalles southward to the Apple river, and eroding the drift bluff, an escarpment of till, which rises steeply on the west side of the valley at Taylor's Falls and northward to the hight of 200 to 220 feet above the river, took place mostly during the prolonged Buchanan interglacial stage. It was a nearly similar history with that of the Minnesota river during the same Buchanan time in the re-excavation of its valley, which had doubtless become chiefly filled with drift during the principal Kansan stage of glaciation.

When I wrote the chapter on this district for the Final Report of the Minnesota Geological Survey (volume ii, 1888, pages 399-425, with map of Chisago, Isanti, and Anoka counties), I believed that the preglacial and postglacial courses of the St. Croix were alike; but I now attribute the establishment of this great river course and valley at the Dalles, and for many miles above and below, to the

* Geology of Minnesota, vol. ii, 1888, pp. 414-418.

capricious outlines of the retreating ice-front in Buchanan time, probably sending a considerable stream across the preglacial watershed and along this course at first because the ice itself was a barrier on the lower country westward. The erosion by this stream had cut down this section of the valley and the two gorges of the Upper and Lower Dalles so far before that lower land was uncovered from the ice that the channel so begun still continued as the lowest then available for the river, and the erosion apparently extended as deep as to the present river level before the renewal of ice accumulation.

The duration of the interglacial stage attended by great decrease of this part of the continental ice-sheet has been estimated by Winchell, from his investigation of the drift-filled gorge of the Mississippi west of Minneapolis, to have measured about 15,000 years.* Within that time, preceded and followed by long stages of glaciation of this district, the drainage from an embayment of the ice boundary, at the junction of glacial currents flowing in Minnesota from the northwest and in Wisconsin from the northeast, passed in a large river, the interglacial St. Croix, across the former watershed where we now have the gorges of the Dalles.

Separate preglacial streams flowing from this locality southward and northwestward during many thousand years of the Tertiary era, in the now continuous river course, had doubtless performed the greater part of the valley erosion on each side of the old watershed, which itself, we may also believe, was deeply indented here by a col of the trappean rocks in which the Dalles are channeled. The separate valleys leading away from the col, as eroded during the very long Tertiary era, may have attained nearly the same size which they now have as parts of the present continuous valley, varying mainly from about a half mile to one mile in width and from 75 feet to about 150 feet in depth below the adjoining rock cliffs.

In the Upper Dalles, at and just south of Taylor's Falls, extending about two-thirds of a mile, and again in the Lower Dalles situated two miles farther down the river and reaching one-third of a mile, immediately above the village of Franconia, Minnesota, the rock cliffs of trap, Keweenawan diabase, rise almost or quite perpendicularly on each side of the river, inclosing it at each place by a very picturesque gorge. The vertically jointed and castellated walls of the Upper Dalles form a gorge from 200 feet to about 500 feet wide, which turns at a sharp angle in its central part from a course nearly due south to another bearing west-southwest. The course of the Lower Dalles, about 500 feet wide, is also west-southwest, this direction being in each case determined by a principal system of parallel and nearly vertical joint planes.

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* Paper before cited in the AMERICAN GEOLOGIST, (vol. x), estimating the interglacial stage as 9,750 years; which is corrected to about 15,000 years in the same volume, p. 302, Nov., 1892.

Between these diabase gorges the valley widens to about a mile, its western rock wall being an escarpment of almost horizontally bedded Cambrian sandstone and shales, easily eroded, while on the east it is inclosed by irregular slopes of the igneous Keweenawan rocks. Continuing south from the Lower Dalles, the valley, a half mile to one mile wide, is inclosed by escarpments of the horizontal Cambrian sandstone capped by dolomitic limestone, with overlying glacial drift. Returning and going up the river from St. Croix Falls, we find its valley there inclosed chiefly by eroded drift bluffs.

Berkey and R. T. Chamberlin regard the very remarkable potholes or giants' kettles of the trap rocks at the Upper Dalles as due to the ordinary river action while cutting down this rock barrier during Postglacial time. Instead, as shown in the second of my papers cited in the Bulletin of the Geological Society, these potholes seem to me due to torrents plunging through moulins of the ice-sheet, probably at a time of stagnation of the glacial currents when the ice here was finally meltng away.

Nearly coincident with the course of the St. Croix river through this Interstate Park was the junction of the diverse icefields, that on the east bringing the red drift from the region of lake Superior, while that on the west brought gray drift from the Red river valley and Manitoba. Though the parts of both icefields in the vicinity of the Dalles were moving easterly, their currents being turned toward the ice boundary and its concentrically curved moraine belts, we cannot doubt that some difference of slope of the ice surface was distinguishable on the east and west sides of this line of junction, when they both were being fed by snowfall and by inflow of glacial currents. But when the final melting had reduced the ice here to a thickness of only a few hundred feet, or at last no more than a few scores of feet, with its former motion at a standstill, or nearly so, we may readily see that the waters of the surface melting might run toward this line of confluence of the diverse Lake Superior and Keewatin icefields; that waterfalls would pour through crevasses and the vertical tunnels called moulins; and that such torrents could erode deep potholes, as here, with little general water-wearing of the contiguous rock surfaces.

These giants' kettles, numbering about a hundred, the

largest about 25 feet in diameter, and the deepest exceeding 80 feet in depth, occur most abundantly near the steamboat landing of Taylor's Falls, at the central part of the Upper Dalles, and within a distance of fifty rods northward. They are unsurpassed by any other known locality, not even excepting the Glacier Garden of Lucerne, in respect to their variety of forms and grouping, their great number, the extraordinary irregularity of contour of the much jointed diabase in which they are eroded, and the difficulty of explanation of the conditions of their origin.

If it be desirable to suggest a probable measure in years for the ages of the gorge and the giants' kettles at the St. Croix Dalles, I would venture to estimate the whole duration of the Ice age as about 100,000 years, of which about half, or 50,000 years, would probably belong to the early or Kansan glaciation; about 15,000 years, according to Winchell, would measure the Buchanan interglacial stage in Minnesota; perhaps 30,000 years may be allotted to the later Illinoian and Iowan glaciation; and the departure of the ice-sheet, in its moraine-forming Wisconsin stage, occupied probably about 5,000 years. Under these estimates, the rock gorge here would be about 40,000 years old, its last 5,000 years being approximately the time since the latest parts of our continental ice-sheet were melted away. For the giants' kettles, about 7,000 or 8,000 years, as I think, may be assigned as their age, being nearly the same as that of the beginning of erosion of the gorge of the Mississippi river between Fort Snelling and Minneapolis.

THE PEGMATYTE VEINS OF PALA, SAN DIEGO COUNTY.*

By G. A. WARING, Stanford University, California.

PLATES XXII—XXVI.

Concerning the region with which this paper deals, Fairbanks† has said: "The structure of San Diego county is comparatively simple. Three main divisions might be made: the desert region on the east, the Peninsular range of crystalline rocks in the middle, and the nearly level mesa on the west. The higher mountains are formed wholly of ancient crystalline schists and massive rocks."

Fig 1 Sketch map of western San Diego County

It is with this middle divison, or rather the part of it lying between Temecula canyon and the Palomares mountains, that we have to deal. The Palomares mountains are composed of mica schists but the lower lying hills and mountains of the region are of granite and dioryte, and according to the writer's observation the structure is that

* The writer is indebted to Dr. J. P. Smith, of Stanford University, for advice in the preparation of this article.

† H. W. FAIRBANKS—Geology of San Diego County; also portions of Orange and Bernardino Counties. *Eleventh Annual Report of California State Mineralogist.* p. 76.

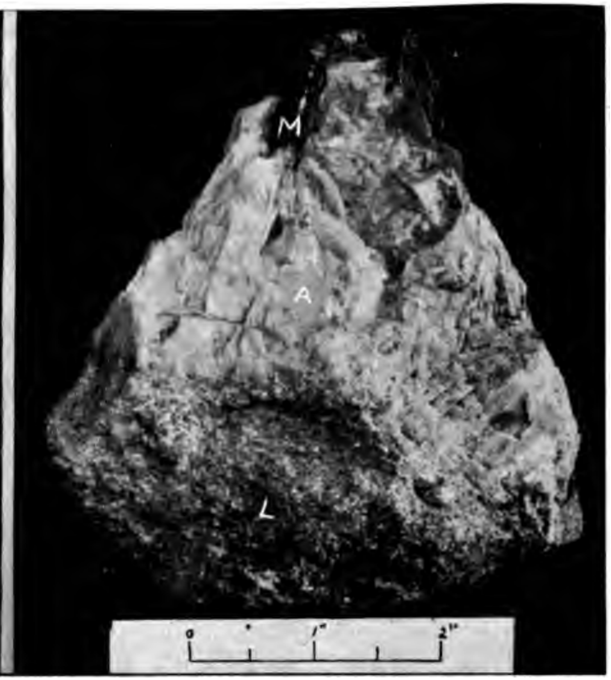


Fig. 1. Graphic Granite. Upper part of pegmatyte veins.
Fig. 2. "Paystreak" matter. Central part of pegmatyte veins. M=Muscovite A=Albite L=Lepidolite.

dipping 45° southwest. The rocks shortly become massive and are replaced by dark syenitic ones with an excess of hornblende. Two miles down, granite appears for a short distance, and in it a quarry has been opened. Gneissoid rocks soon replace the granite and these are followed by hornblendic rocks which vary from a schistose to a massive structure. In places they contain feldspars and pass into syenytes; in others the rock is almost pure hornblende. The syenytes are followed by mica schists and these by coarse biotite granite about five miles above Howe [Fallbrook] station. In the granite are many pegmatitic veins, carrying biotite, garnets, and tourmaline. Fine-grained granite, varying at times to syenyte, forms the rock along the cànyon for many miles below this point."

Topography. The Fallbrook region is a rolling plateau of from six hundred to eight hundred feet elevation. From Oceanside to within five miles of Pala, the San Luis Rey river lies in a broad sandy valley. The mountains then close in for about two miles, making a narrow canyon, but at Pala the river valley opens out into a flat alluvial plain, from one to two miles wide, extending south-eastward to the foothills at Rincon. Loose boulders and gravel strew the floor of this plain and of the small side valleys. The river keeps close to the south side of the valley and a few miles above Pala has cut a channel in this wash formation nearly one hundred feet below the floor of the plain.

Veins and Dykes. The large intrusive dioryte areas are cut by veins composed chiefly of feldspar, biotite and black tourmaline. Many small veins also cut the granite area, but these contain only feldspar and biotite, without tourmaline.

Two regions of apparently intrusive granite have been observed, the beryl region of Rincon, which will be described later, and a small area four miles soueheast of Fallbrook. At the latter place two prospect shafts have been sunk, one of six feet, the other of twenty-six feet in depth, on a pegmatyte vein in search for gems. This vein is about twenty inches wide, striking N.-S. and dipping 80° to the east. The vein is well defined from the decomposed country rock. It does not outcrop, but is marked by a local

Fig. 1. Garnet Quartzyte. Lower part of pegmatyte veins. Dark bands are composed of minute garnets.
Fig. 2. Quartz crystal intergrown with muscovite (M) and albite (A).

more resisting character of the granite on the east wall, making a distinct ridge about ten inches high and two feet wide. A slight pegmatitic structure is shown in the west side of the vein. The whole width consists of quartz, feldspar, and muscovite. A little fibrolite is developed near the center of the vein,—a mineral not known to occur in any other vein of the region. A few pockets have been found here, and some fine specimens of quartz enclosing black tourmalines taken out, but no gems.

About two miles southwest of Fallbrook station, in Temecula canyon there is a dyke of hypersthene dioryte and in it a pegmatitic vein several feet wide. This shows a graphic structure on the hanging-wall side and a banded garnet quartzyte on the footwall side. Muscovite and black tourmaline are developed to considerable extent but otherwise the vein is not mineralized.

Structure of the Pegmatyte Veins. This pegmatic structure is best developed in an area about one and a half miles wide and four miles long, lying northeast of Pala, as shown in fig. 2. This consists of a noryte boss within the

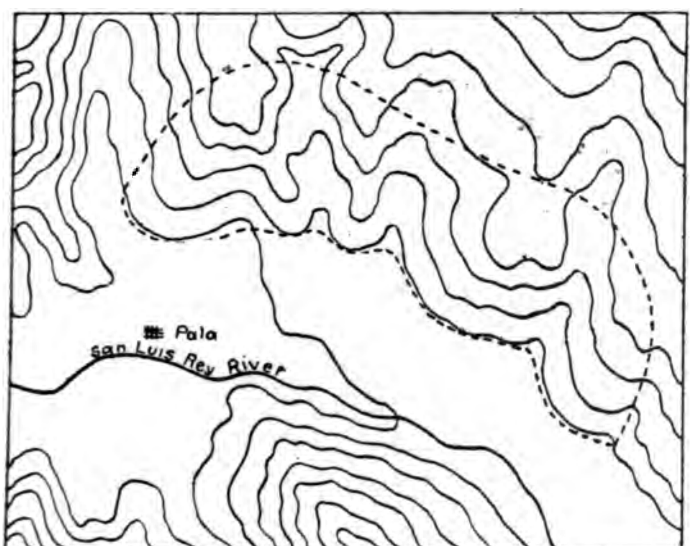


Fig 2 Contour map of Pala Region.
Scale ½ 1 mile

granite. The contact with the granite is well marked on the east, north, and west; on the south it is covered by the loose gravels of the valley. A number of pegmatyte veins cut through the noryte, dipping rather uniformly S. 45°--50° W. at an average angle of about 30° with the horizontal. These veins have a very uniform structure, like that shown in fig. 3. There is a distinct contact between

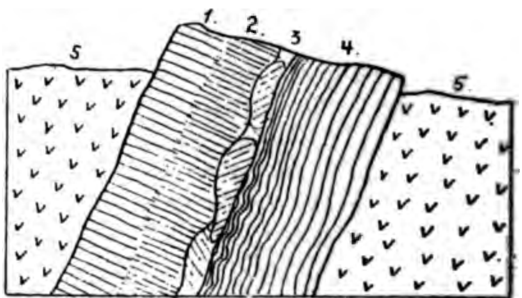
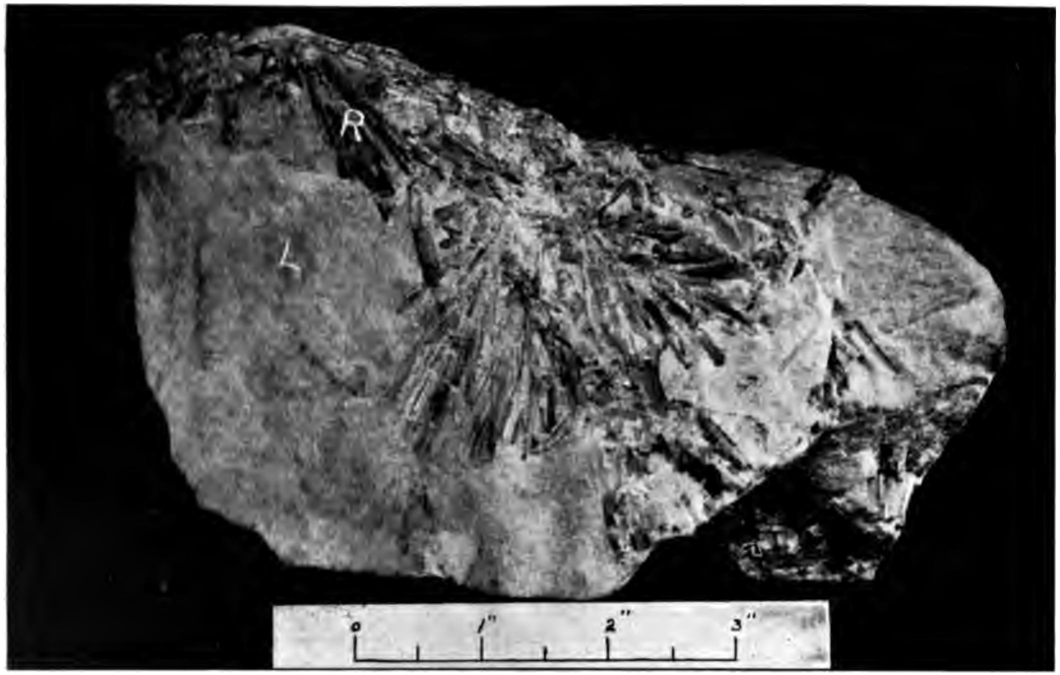


Fig 3. Dyke Structure.
1 Coarse Pegmatite.
2. Graphic Granite.
3. "Paystreak".
4. Garnet quartzite.
5. Norite.

the noryte (5) and upper portion of the vein. This upper portion (1) consists of a coarsely crystalline pegmatyte rich in mica and black tourmaline. This grades into a fine grained graphic granite (2) in which is often a little mica. Plate xxii, fig. 1, is of a hand specimen of this rock. The graphic granite grades downward into the "pay-streak" (3) in which the rarer minerals are found. Fig. 2, plate xxii. shows a piece of this part of the vein, containing lepidolite, albite and muscovite. Pockets occur in this layer, lined with crystallized quartz and feldspars and containing crystals of tourmaline, kunzite and orthoclase, usually embedded in a clayey matrix. Between the paystreak and lower portion (4) of the vein the contact is sharp. This lower part consists of a banded garnet quartzyte, making a distinct contact with the noryte. A peculiarity of this is that it always composes one-half the thickness of the vein and that the minute garnets have a banded arrangement, often



Lepidolite (L) containing radiating crystals of rubellite (R).

much crumpled. Plate xxiii, fig. 1, is of a hand specimen of this rock.

Veins of the Pala Region. By far the largest and most distinctive vein is near the western side of the noryte boss. The outcrop is on the east slope of the hill and is plainly traceable for over half a mile. The northern portion consists mainly of pegmatyte, with no tourmaline or lepidolite. About the middle of its exposed length, black tourmalines appear in a coarse quartz-feldspar-mica matrix. Often these tourmaline crystals, several inches in length, are broken into many pieces and displaced slightly. Lepidolite begins to show here in small veins, and farther south at the lithia mine, it develops into a large mass—60 feet through in the thickest place. This mass consists of small particles of lithia mica and feldspar. Near the southern end of this are found the beautiful specimens containing radiating bunches of rubellite, a specimen of which is shown in plate xxiv. Still farther toward the southern end of the outcrop only black tourmaline occurs.

Two smaller veins outcrop on this hill, farther west, and exposed higher up. On them are located the Tourmaline King and Tourmaline Queen mines, from which some gem tourmalines have been taken. The next vein of note east of the big lithia deposit is that of the Pala Chief kunzite mine. The vein has the same structure as the others; pockets seem more plentiful, however, and in them are found quartz crystals of large size. The eastern part of this noryte area contains many veins, often only a few feet apart. Some difference in the occurrence of the rarer minerals is noted in the veins though no strict rule is followed. In a general way, however, in the westernmost veins lepidolite is more plentiful, tourmaline in the more central, and kunzite in those to the east.

Character of the Intrusive Rocks The gabbro of this area varies in texture from a fine-grained hypersthene rock to one containing large feldspars with only green hornblende. Near the eastern end of the noryte is a small area, only a hundred yards in extent, over which the surface is strewn with rounded pebbles from one to three inches in diameter. These "orbicules" have resulted from the

weathering of an orbicular gabbro, resembling that of Dehesa, California, described by Lawson* and by Kessler and Hamilton.† A few hundred yards to the west the orbicular rock gives place to a very coarse-grained gabbro, which grades into the noryte.

Minerals Occurring in the Pockets. The minerals occurring in the pockets of the veins are: quartz, crystallized out on the sides, both of the clear and smoky varieties. These crystals are notable for the rather common development of rare crystal faces. Hyalite and rose quartz are also sometimes found. Albite occurs with quartz, lining the pockets, and has a tabular habit of crystallization. Orthoclase is usually found in pockets as individual crystals in the clay and is of the aventurine variety. It consists of microcline and albite in alternate bands. Muscovite, usually of a greenish tint, is found in plates of considerable size within the pockets, as scales or flakes making up a considerable part of the clay, and as minute scales included in other minerals. Lepidolite when found in pockets is usually near the central part, and embedded in it are often found gem tourmalines and kunzite. This latter is often in fresh fragments and splinters, and also in fragments showing corrosion or decomposition.

Crystals tend to grow to large size in these pockets. Although any one mineral may occur to the exclusion of the others, when several are found together, the orthoclase and kunzite are near the center, while the albite and lepidolite are near the walls. It is rare that kunzite and tourmaline occur in the same pocket. Even when in the same ledge, they are some distance apart.

Vein Minerals Quartz, albite, muscovite and black tourmaline make up a good part of the paystreak. The mica often shows a crossing of plates as if of twinning but this is not shown by the optical figure. It is probably due to crushing or sliding action. The black tourmalines are also often intergrown and distorted, besides being broken. Lepidolite, varying in quality from the nearly pure lilac-

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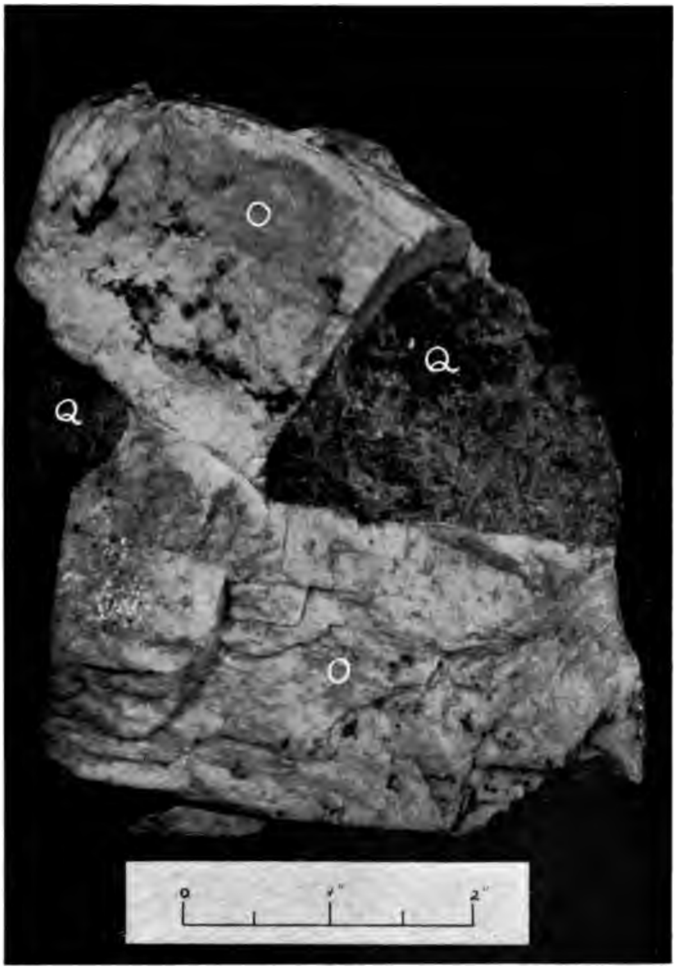
* *Bull. Dept. Geol. U. Cal. vol. iii No. 17. Mar. 1904* The Orbicular Gabbro at Dehesa, San Diego, Co., Cal., by A. C. LAWSON.

† The Orbicular Gabbro of Dehesa, Cal., by H. H. KESSLER and W. B. HAMILTON, The AMERICAN GEOLOGIST. Sept., 1904.



Coarse pegmatyte from Rincon, Q=Quartz, O=Orthoclase.

colored lithia mica to that containing much feldspar, and amblygonite occur in masses of several tons weight. The amblygonite is found as a rule below the lithia deposits. Triplite is found in masses of several pounds weight, almandine and vermiculite occur to some extent, and about five pounds of sulphide of bismuth have been found in one place in amblygonite. This is the only metallic mineral so far known in this locality.

Clays in the Veins. At least three kinds of clay from the kunzite bearing pockets are recognized, known locally as kunzite clay, kunzite and tourmaline clay, and lithia clay. A physical analysis of these has been made, by specific gravity methods.

Below is the average mineral composition of them:

	Kunzite Clay No. 1.	Kunzite Clay No. 2.	Lithia Clay	Kunzite and Tourmaline Clay.
Quartz	40.%	36.%	36.%	24.5%
Feldspar Albite and Orthoclase	43.	50.	50.	58.2
Muscovite	6.	10.	10.	4.8
Spodumene	10.9	1.3		
Lepidolite		2.5	3.	
Halloysite				12.3
Tourmaline	.1 (Blk)	.2	1. (Green)	.2 (Pink and Green)
	100.0	100.0	100.0	100.00

These analyses show that the amount of feldspar and quartz is about the same in all—83% to 86%—while the percentages of muscovite and rarer minerals vary considerably.

The halloysite is a pink clay apparently derived from rubellite, for all gradations from unaltered tourmaline to the chalky clay can be found. An analysis of it as given by W. T. Schaller* is as follows:

* *American Journal of Science, Mar. 1904.* Notes on some California Minerals. By WALDEMAR T. SCHALLER

SiO^2		LiO^2	.23
Al^2C^3	35.55	Na^2O	.19
Fe^2O^3	.21	K^2O	.03
MnO	.26	H^2O (107°)	6.63
CaO	1.02	H^2O (above 107°)	12.25
MgO	.19	TiO^2	none
			100.18

This analysis agrees closely with the formula $H^4Al^2Si^2O^9+H^2O$. It will be noticed that no boron was found in this clay.

A small amount of a white finely granulated mineral has also been found in the pockets. The microscope shows it to be composed almost wholly of fresh angular fragments of feldspar, which contains manganese.

The Rincon District. Eastward toward Rincon the vein structure again becomes evident on the north side of the valley, and at the base of the Palomares mountains above Rincon another mineralized area occurs. But here the country rock is mainly a decomposed granite, with the veins standing out prominently. These have the usual structure but the association of minerals is somewhat different. Crystals of quartz, orthoclase and beryl are the pocket contents. Black tourmaline, patches of massive almandine and large beryls are common in the hard pegmatitic material. Greenish muscovite is also very noticeable in patches several inches in extent. The pegmatyte in some places has a very coarse structure in which the individual quartz and orthoclase crystals are several inches in extent, as shown in plate xxv.

Only two veins have been prospected enough to show the occurrence of minerals. From the lower of these, over $2,000 worth of gem beryls have been taken with the removal of hardly a hundred cubic yards of material. The beryls occur in clay in pockets usually not over eight inches in diameter, in the central portion of the ledge. In the upper vein are found many pockets filled with a red clay composed of mica and iron-stained kaolin. Many small beryls occur in this, but are uniformly of a milky hue. Smoky quartz, often intergrown with mica (plate xxiii, fig. 2), and orthoclase crystals (plate xxvi, fig 1), several inches in diameter are found in the larger pockets. The latter are

of the aventurine variety, and the surface is often corroded into a series of sharp ridges by the removal of microcline and greater resistance of the albite to alkaline waters, as shown in the twin crystal illustrated. Iron oxide also seems to be deposited by these waters, in the interstices of the crystals, staining them red. Many of the beryls are also corroded or partly dissolved, as shown in plate xxvi, fig. 2.

Neither kunzite, lepidolite nor amblygonite has yet been found in this region. Albite also is rather uncommon.

Spring Waters The waters of three springs—one from Rincon and two from near Pala—have been tested spectroscopically for lithia but show no trace. They are all three alike in containing only about eighteen grains of solid matter to the U. S. gallon. This consists mostly of the chlorides and carbonates of potassium, sodium and calcium.

Origin of the Veins, All the observed facts point to the hydrothermal origin of these veins. As Lehmann* expresses it; "as a result of crystallization of a parent mass and the concentration of water in the residual uncrystallized part, a gelatinous magma rich in silica is formed. Between such a gelatinous magma and a saturated aqueous solution a large number of consecutive intermediate stages can be imagined." Such a cooling and crystallizing magma would fulfill all the conditions demanded by the structure of the veins of this region. The three phases of pegmatization as given by Van Hise† seem exhibited in these dykes.

The graphic granite without doubt represents crystallization from a solution mainly aqueous, the central mineralized portion hydro-thermal action, while the lower garnet quartzyte crystallized from a more gelatinous magma.

Thin sections of the graphic granite cut perpendicular to the long axes of the crystals show the quartz all to be oriented the same way. Sections of the garnet rock show the minute garnets to be perfectly formed. The follow-

* Monograph xlvii U. S. Geol. Survey. VAN HISE *A treatise on Metamorphism.* p. 722.

† Monograph xlvii U. S. Geol. Survey. VAN HISE. *A treatise on Metmorphism.* p. 725.

ing points advanced by W. O. Crosby and M. L. Fuller‡ in support of the aqueo-igneous theory are all borne out by the character of the veins in question. They are: the occurrence of rare minerals; the formation of large crystals; the banding and comb structure of tourmalines, etc. normal to the walls; water inclusions in the quartz; and the occurrence of pockets and druses. There is always one normal plutonic rock in every pegmatyte region, of similar but less acid character, from which the pegmatyte is evidently derived. The normal country granite apparently occupies this position here.

In summary Van Hise says: "Pegmatization when it occurs on a great scale usually is found in connection with great intrusive masses in which there have been long-continued composite intrusions. No great batholith is the result of a single simple intrusion. The introduction of such masses went on irregularly through a very long time. Pegmatyte masses are not the result of a distinct epoch of eruption, but usually are produced in connection with the closing phases of igneous activity. * * * As the pegmatytes close to the central mass solidify, a large portion of the water is expelled and travels outward to help form the pegmatyte rock having a more distinctive vein character."

As before stated, the banded quartzyte very constantly forms the lower half of the Pala and Rincon pegmatitic veins. In explanation to this it is now suggested that this material first occupied the fractures in the cooling noryte boss as a hydrous magma, and that on crystallizing it contracted to approximately half its former volume. Toward the later stage of crystallization garnets developed, aided by contact action of the noryte, but were unable to reach any considerable size. Later a more aqueous magma was forced up through the reopened crevices and formed the upper portion of the veins. The pockets seem to be of later origin. The crystallization in them of the residual rare elements as complex silicates and the occurrence of large quartz and orthoclase crystals supports this theory.

‡ CROSBY, W. O. and FULLER, M. L., Orgin of Pegmatite. *Tech. Quar. Vol. 9, 1896, pp. 326-356.*

Fig. 1. Orthoclase crystal form Rincon, showing corrosion due to meteoric waters.

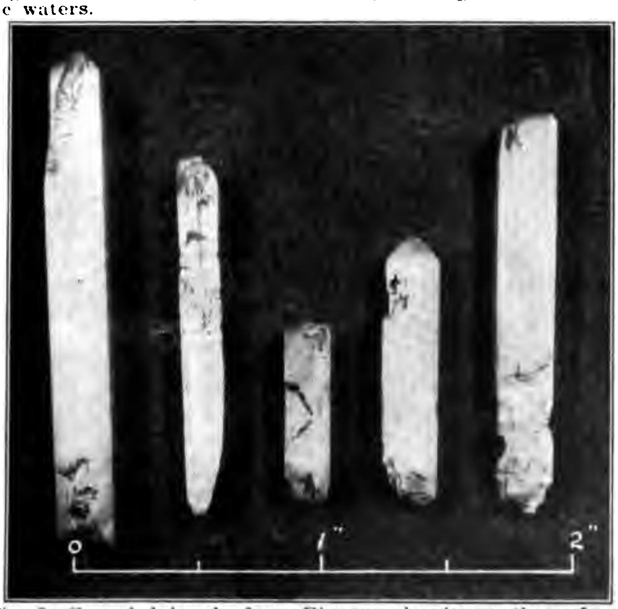


Fig. 2. Corroded beryls from Rincon, showing action of meteoric waters.

None of the minerals of the rare elements, tourmaline, spodumene, beryl or lepidolite, occur outside of the pegmatitic formation.

None of the common rock-forming minerals could take up these rare elements, and an igneous magma is not conducive to their crystallization as complex silicates; hence they remained uncombined until forced out with the eruption of the pegmatyte. In this hydrous magma conditions were favorable, so they crystallized out as the rarer silicates. The plentiful occurrence of tourmaline indicates fumarole action also to have been a prominent factor in this period.

Types of Veins. The different types of veins observed may now be summed up into six classes.

1. Veins in the normal granite, containing only orthoclase and biotite.

2. Veins in the normal dioryte, containing quartz, feldspar, biotite and black tourmaline.

3. The pegmatitic vein in intrusive (?) granite, (east of Fallbrook), containing quartz, feldspar, mica, black tourmaline, fibrolite, and quartz crystals enclosing black tourmalines.

4. The pegmatitic vein in hypersthene dioryte (in Temecula canyon) showing graphic granite and banded quartzyte structure, but not mineralized.

5. Pegmatyte veins of Pala in noryte, highly mineralized, containing lepidolite, amblygonite, spodumene, tourmaline, quartz and feldspars.

6. Pegmatyte veins of Rincon in intrusive (?) granite, also mineralized but with a different association of minerals—quartz, orthoclase, muscovite and beryl.

From the previous discussion it is seen that the most highly mineralized veins are in an area of noryte—a basic hypersthene rock. The more acid hypersthene-bearing dykes show the pegmatitic structure, but are not mineralized, while in normal dioryte and granite, no pegmatitic structure was observed.

The present surface near Pala probably represents the original zone of anamorphism at the time of intrusion, while the more acid diorytes of Fallbrook may represent an or-

iginal zone nearer the former surface. In support of this theory are advanced: (1) the evidences of great erosion shown in and about the Pala valley, (2) the more basic nature of the rocks, according with deeper seated conditions, (3) the occurrence of the heavy minerals—garnet and triplite—and especially of the suphide of bismuth, (4) the shape of the noryte area, more resembling a neck or boss than a dyke. The occurrence of epidote and fibrolite—secondary minerals typical of the zone of katamorphism—in the Fallbrook, but not in the Pala region, is another point in support of this theory. Of the two hornblende granulytes studied, occurring as small dykes in the country rock, that from Pala shows more tendency toward recrystallization of the minerals, than does the Fallbrook rock, also indicating a greater depth of formation for the former. The general occurrence of potash feldspar in the triclinic form, microcline, may be taken partly as an evidence of pressure due to depth, though it is the usual variety occurring in pegmatytes. Several minerals show the effects of crushing and slight displacement, as black tourmalines and crossed plates of mica. The fresh granulated feldspar also shows the results of crushing. Evidently considerable orographic movement has caused this.

Alterations of the Minerals. Since the time when erosion brought the present accessible part of the veins above the zone of anamorphism considerable alteration of the minerals has taken place. The spodumene is often fractured and pitted and contains patches of kaolin-like material. The alteration to beta-spodumene and finally to muscovite and albite as in the Branchville, Conn. variety is not shown in thin sections of the Pala mineral. The decomposition of rubellite to halloysite has been mentioned. Vermiculite occurs to some extent as an alteration of the mica, especially at Rincon. The alteration of microcline and albite to kaolinite and muscovite with the liberation of silica and the alkaline carbonates seem to take place to considerable extent, and is thought to be the origin of the clay of the pockets. These reactions take place with a decrease in volume of from 5% to 16%, assuming the silica to crystallize as quartz and the carbonates to be carried off in solu-

tion,—facts according with the conditions revealed in newly opened pockets. Perhaps the best example of alteration is presented in the pockets at Rincon. Here corroded crystals of orthoclase (plate xxvi. fig. 1) and corroded beryls (plate xxvi. fig. 2) occur together in a matrix of sticky red clay composed for the most part of iron-stained mica and kaolin. It seems clear that the microcline has first yielded to the meteoric waters and been reduced to kaolin and mica. The waters, made more alkaline by the liberated potash, have then attacked the beryls and partly dissolved them. Muscovite often occurs as fine flakes on the larger beryls, seemingly as a product of alteration. The very interesting series of reactions that have taken place here well deserve further study. The relation of the amblygonite to lepidolite, the decomposition of spodumene and the reactions between the feldspars and beryl especially present reactions worthy of examination. Some attempt has been made to trace the rare elements when alteration takes place, but no secondary minerals of boron or beryllium, derived from tourmaline or beryl, are known to occur; neither do ordinary tests show the presence of these elements in the surface waters. It seems probable however that they are carried off as soluble salts, but in quantities so small as easily to escape notice. The failure to find lithia in these waters might be expected, for the lepidolite is always fresh and unaltered.

THE SALT DEPOSITS OF NORTHEASTERN OHIO.*

J. A. Bownocker, Columbus, Ohio.

PLATE XXVII.

Introduction. The first settlers of the territory of Ohio found salt one of the most expensive necessities. Not a pound was produced in the territory, nor was there a supply west of the Alleghanies. In consequence, salt had to be transported across the mountains, making the cost to the settlers from four to eight dollars per bushel. So heavy was this burden that many thought it would permanently handicap the development of the territory.

However, when the hills of the southeastern portion of the territory were explored, the situation was found to be more favorable. Salt springs were discovered and these would at least yield a partial supply, thus helping keep the price of salt within the reach of all.

Probably the first salt made by white men on land now forming part of Ohio was on the banks of Salt creek in what is now Jackson county.† The brine was obtained directly from springs or from shallow wells, and evaporated in iron kettles. Brines were found also in the valleys of the Muskingum, Duck creek and other streams. Salt furnaces were built in many places, thus making the people independent of an eastern supply.

These furnaces flourished for many years, but the competition of New York and Michigan with their much stronger brines proved too much and one by one the furnaces of Ohio were abandoned. About the year 1890 salt making was practically restricted to Pomeroy and vicinity in the valley of the Ohio river, that locality having fuel in the adjacent hills and water transportation for the manufactured product. These advantages, however, great as they were, would not have been sufficient to keep the industry alive. The brines contain bromine and calcium chloride, and it is these by-products that have saved the Pomeroy furnaces from the fate of others in that part of Ohio.

So great had been the decrease in the manufacture of

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* Published by permission of Edward Orton, Jr., State Geologist of Ohio.

† Am. Jour. of Sci. and Arts. Vol. 24, p. 46.

salt that in 1890 the state produced only two and six-tenths per cent of the total yield of the United States, ranking sixth among the states. Less than ten years earlier Ohio produced over six per cent of the total and was surpassed by New York and Michigan only.

Salt Discovered in Northeastern Ohio. About 1886 when it seemed that Ohio must cease to be a large salt producer, an important discovery was made. In drilling for natural gas at Newburg, near Cleveland, rock-salt was found. This well was the deepest that had been drilled up to that time in northeastern Ohio, and furnished valuable data on the stratigraphical succession of that part of the state.

The driller's log as interpreted by Dr. Edward Orton is as follows:*

		Thickness of Formation.	Total Depth.
Drift		40 ft.	40 ft.
Ohio and Bedford shales		1310 ft.	1350 ft.
Corniferous and Monroe formations	Limestone	290 ft.	1990 ft.
	Sand containing lime	40 ft.	1700 ft.
	Limestone	310 ft.	1660 ft.
Salina formation	Rock-salt and shale	164 ft.	2154 ft.
	Shale	15 ft.	2169 ft.
	Limestone	81 ft.	2250 ft.
	Rock-salt	50 ft.	2300 ft.
	Shale, blue	40 ft.	2340 ft.
	Sand	20 ft.	2360 ft.
	Shale	18 ft.	2378 ft.
	Limestone	22 ft.	2400 ft.
	Rock-salt	20 ft.	2420 ft.
	Shale	10 ft.	2430 ft.
	Limestone	40 ft.	2470 ft.
	Rock-salt	5 ft.	2475 ft.
	Shale	8	2483 ft.
Niagara formation	Limestone	167 ft.	2650 ft.
	Oil-sand	8 ft.	2658 ft.
	Limestone	22 ft.	2680 ft.
	Oil-sand	6 ft.	2686 ft.
Clinton formation	Limestone	64 ft.	2750 ft.

* Geol. Survey of Ohio, Vol. vi, p. 352.

Later drilling was continued through "limestones of the same general character" to a depth approximating 3,000 feet when the tools became fast, and hence work ceased.

The 40 feet of sandstone found at a depth of 1,660 feet has been reported in other places. Dr. Orton thought it the equivalent of the Sylvania sand found in Lucas county. As is well known the latter formation lies in the Monroe formation, and hence cannot belong to the Oriskany as some have thought. The sand is found at a corresponding horizon in the deep wells at Barberton, Summit county, Wayne county and at Jefferson, Ashtabula county. It is this formation that contains the oil and gas at the latter place.* The presence of this stratum at widely different places shows that it is more important stratigraphically than has been heretofore recognized.

Chemical analyses have been made from drillings taken at several horizons. These show that the shales associated with the rock-salt consist largely of calcium sulphate, and that the top of the Niagara is strongly magnesian and the lower part almost a pure dolomyte.†

Not finding the desired fuel in commercial quantities in this well, attention was given to the salt, with the result that the manufacture of this article was soon begun. The industry has been extended to other places with the result that in 1903 Ohio produced nearly 15 per cent of the total for the United States, and again took third place, being surpassed by New York and Michigan only.

Records of Other Wells. Shortly after the furnace was constructed at Newburg, one was built in Cleveland, the location being on the lake front at the foot of Madison street. Brine is supplied by five wells, each approximating 2,000 feet in depth. Following is a log of well No. 4:

Drift	267 ft.
Ohio and Bedford shales	723 ft.
Coniferous and Monroe formations	785 ft.

* Geol. Survey of Ohio, Bull. I, 4th Ser. p. 88.
† Geol. Survey of Ohio, Vol. vi. p. 354.

Salina formation	Rock-salt and limestone	10 ft.
	Rock-salt	16 ft.
	Limestone	16 ft.
	Rock-salt	19 ft.
	Limestone	4 ft
	Rock-salt	59 ft.
	Limestone	21 ft.
	Rock-salt	37 ft.
	Limestone	4 ft.
	Rock-salt	37 ft.
	Shales	16 ft.

This log does not show the sandstone in the Monroe. This is believed, however, to be due to the imperfection of the record, and not to the absence of the formation. It is worthy of note that this well shows 168 feet of rock-salt.

Five years ago the Cleveland Salt Company began work, the plant being located at the intersection of Second and Central avenues. The wells are about 1,950 feet deep, but no detailed record was kept of the strata above the Salina. The latter consists of beds of salt varying in thickness from 5 to 72 feet, alternating with limestone strata ranging in thickness from 5 to 22 feet.

About 1889 a well in search of oil was begun at Wadsworth in the southeast corner of Medina county. Progress was slow, more than a year elapsing before a satisfactory depth (3,200 feet) was reached. Oil was not found and but little gas. However, at about 2,400 feet rock-salt was discovered. The stockholders were not ready to make use of this, and accordingly the well was abandoned. A year or two later a company was organized and the manufacture of salt begun. Brine is secured from four wells approximating 2,700 feet in depth. Records of the strata were not kept, but the manager of the works reports that four beds of rock-salt were found, aggregating 140 feet in thickness.

In the autumn of 1898 the Ohio Salt Company began making salt at Rittman in the northeast corner of Wayne county. The following records of wells Nos. 1 and 3 show the stratigraphical succession:

NUMBER 1.

Drift	173 ft.
Berea sandstone	20 ft.
Bedford and Ohio shales	1842 ft.

Corniferous and Monroe formations	Limestone	268 ft.
	Sandstone (gray)	30 ft.
	Limestone (shelly)	225 ft.
Salina formation	Rock-salt	66 ft.
	Total depth	2624 ft.

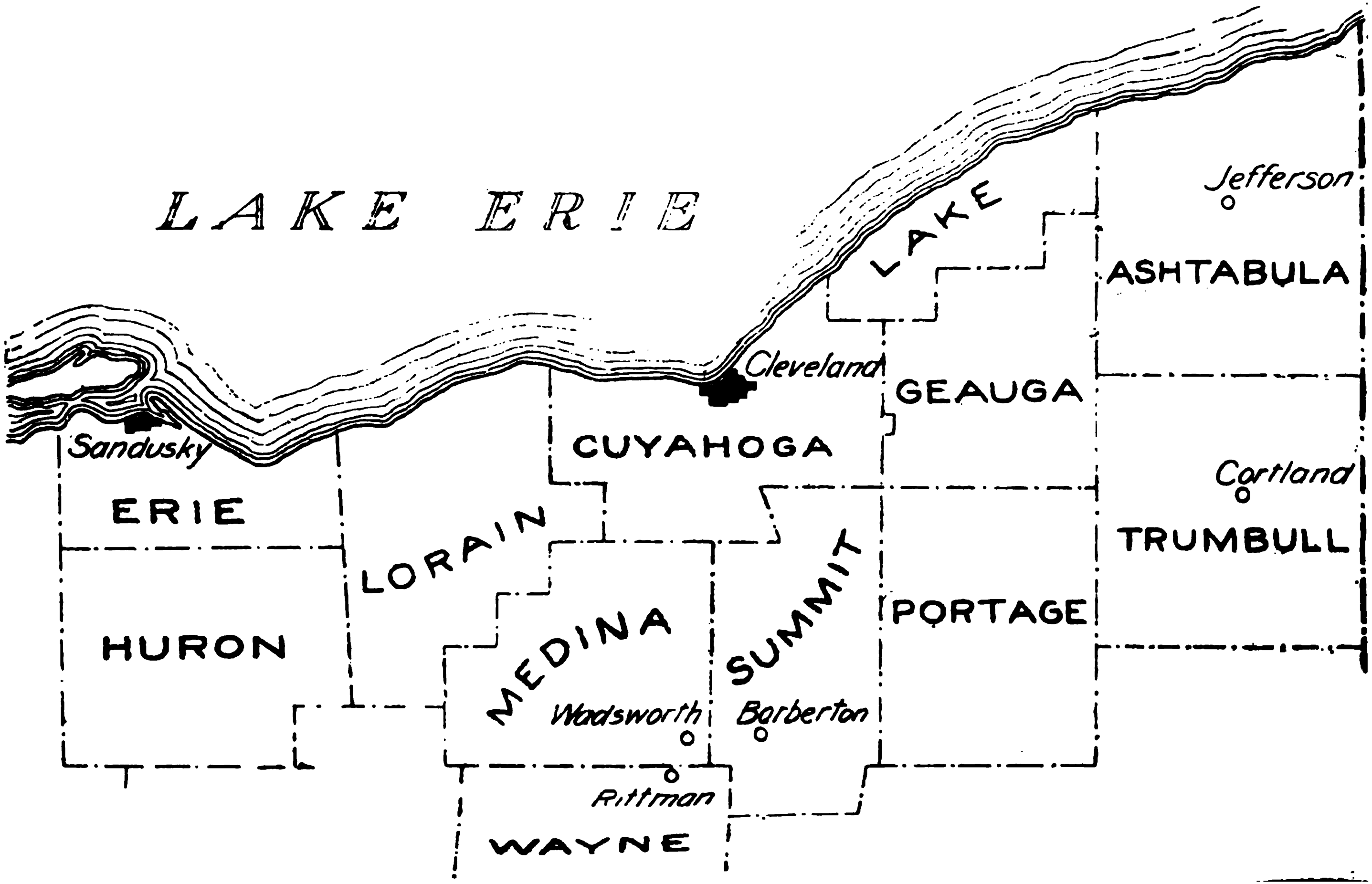
Work ceased when the first bed of salt was penetrated, but in well No. 3 the drill was forced deeper.

The lower part of this record follows:

Base of Monroe formation at		2516 ft.
	Rock-salt	6 ft.
	Limestone	25 ft.
	Rock-salt	30 ft.
	Limestone	5 ft.
	Rock-salt	35 ft.
	White slate	30 ft.
	Limestone	7 ft.
	Total depth	2654 ft.

The Colonial Salt Company, located at Kenmore between Akron and Barberton, has drilled six or seven wells to a depth of about 2,900 feet. At Barberton a few miles farther south the Columbia Chemical Company also has drilled several deep wells for salt used in the manufacture of soda-ash. Below is the record of well No. 1 of this company:

Drift		90 ft.
Slate, black, soft		45 ft.
Sand, black, soft		15 ft.
Cuyahoga and Sunbury (Berea) shales		310 ft.
Berea grit		10 ft.
Bedford and Ohio shales		1710 ft.
Corniferous and Monroe formations	Lime, brown, very hard	60 ft.
	Lime, gray, very hard	80 ft.
	Lime, white	150 ft.
	Lime, gray	30 ft.
	Sand, brown, very hard	30 ft.
	Lime	244 ft.


LAKE ERIE
Sandusky
ERIE
HURON
LORAIN
CUYAHOGA
Cleveland
MEDINA
Wadsworth
WAYNE
Rittman
SUMMIT
Barberton
LAKE
GEAUGA
PORTAGE
ASHTABULA
Jefferson
TRUMBULL
Cortland

Salina formation.	Rock-salt	30 ft.
	Lime	16 ft.
	Rock-salt	5 ft.
	Lime	5 ft.
	Rock-salt	69 ft.
	Lime	107 ft.
	Total	3006 ft.

One more record will be given. This is of a well near Cortland, Trumbull county. The well was drilled for oil or gas.

Drift		40 ft.
Shale		60 ft.
Berea grit		160 ft.
Bedford and Ohio shales		2396 ft.
Corniferous and Monroe formations		583 ft.
Salina formation	Rock-salt	12 ft.
	Limestone	5 ft.
	Rock-salt	2 ft.
	Limestone	3 ft.
	Rock-salt	10 ft.
	Limestone	50 ft.
	Rock-salt	29 ft.
	Limestone	10 ft.
	Rock-salt	52 ft.
	White shale	18 ft.
	Limestone	35 ft.
	Rock-salt	10 ft.
	Limestone	27 ft.
	Total depth	3502 ft.

South from Cortland no wells have been sunk to the horizon of the salt beds, and hence the extent of the deposits in that direction can not be given. , Farther west Barberton, Wadsworth and Rittman mark the southern line of exploration. The great difficulty of making tests lies in the depth of the formation sought after. The Ohio shales, which lie above the great limestones, thicken rapidly to the east and south, attaining nearly 2,400 feet along the Pennsylvania line.

At Sandusky a well, drilled for oil and gas, gave the following rock succession:*

* Geol. Sur. of Ohio, vol. vi. p. 195.

Drift	10 ft.
Corniferous limestone	100 ft.
Monroe and Niagara formations	970 ft.
Niagara shale and Clinton formation	105 ft.
Medina shale	175 ft.
Cincinnati shale and limestone	500 ft.
Utica shale	310 ft.
Trenton limestone at	2210 ft.

The Monroe and Niagara limestones were found to contain gypsum, fourteen different layers having been penetrated. The highest lay 110 feet below the summit of the limestone and the lowest was near the base. No rock-salt, however, was found, and hence the salt beds do not extend as far west as Sandusky. However, the area beneath which these deposits have been demonstrated to lie, and the thickness of the beds in question show that Ohio contains enough salt to supply the entire country for an indefinite period.

MINERALOGICAL SYNONYMS.

(From the Mineralogical Magazine, May, 1905.)

New names are still being given to imperfectly described minerals, but it is satisfactory to observe that many of these doubtful species, as well as some earlier ones, are being proved to have no existence. Such names need, therefore, only burden the lists of synonyms in the larger works of reference. Amongst identities recently proved, or suggested on good grounds, the following may be noted:

Conchite = aragonite (R. Brauns, Centralbltt Min., 1901, p. 134; H. Vater, Zeits. Kryst. Min., 1901, vol. xxxv, p. 149).

Coolgardite = coloradoite + calaverite, &c. (L. J. Spencer, Min. Mag., 1903, vol. xiii, p. 268.)

Dimorphite = orpiment (S. Stevanović, Zeits. Kryst. Min., 1904, vol. xxxix, p. 18).

Goldschmidtite = sylvanite (C. Palache, Amer. Journ. Sci., 1900, ser. 4, vol. x, p. 422).

Hessenbergite = bertrandite (F. Grünling, Zeits. Kryst. Min., 1904, vol. xxxix, p. 386.)

Huelvite = rhodochrosite + tephroite (Chemiker-Zeitung, 1903, Jahrg. xxvii, p. 15).

Hussakite = xenotime (E. Hussak and J. Reitinger, Zeits. Kryst. Min., 1903, vol. xxxvii, p. 563).

Hydrogiobertite = brucite + ? (L. Brugnatelli, Centralbratt Min., 1903, p. 148).

Kalgoorlite = petzite + coloradorite (L. J. Spencer, Min. Mag., 1903, vol. xiii, p. 268).

Kilbrickenite = geocronite (G. T. Prior, ibid., 1902, vol. xiii, p. 186).

Ktypeite = aragonite (H. Vater, Zeits. Kryst. Min., 1901, vol. xxxv, p. 149).

Lacroisite = rhodochrosite + rhodonite (Chemiker-Zeitung, 1903, Jahrg. xxvii, p. 15).

Lussatite = tridymite (F. Slavík, Centralblatt Min., 1901, p. 690).

Mamanite = polyhalite (J. H. van 't Hoff and G. L. Voerman, Sitz.-ber. Akad. Wiss. Berlin, 1904, p. 984).

Martinite = monetite (A. de Schulten, Bull. Soc. franc. Min., 1901, vol. xxiv, p. 325).

Metabrushite = brushite (A. de Schulten, ibid., 1903, vol. xxvi, p. 14).

Mooraboolite = natrolite (Min. Mag., 1903, vol. xiii, p. 373).

Palacheite = botryogen (A. S. Eakle, Amer. Journ. Sci., 1903, ser. 4, vol. xvi, p. 379).

Plusinglanz = argyrodite (A. Frenzel, Min. petr. Mitt. (Tschermak), 1900, vol. xix, p. 244).

Ramosite = basic volcanic scoria (L. McI. Luquer, Amer. Journ. Sci., 1904, ser. 4, vol. xvii, p. 93).

Reinite = wolframite pseudomorphous after scheelite (T. Wada, Minerals of Japan, Tōkyō, 1904, p. 76).

Simonyite = blödite (F. M. Jaeger, Min. petr. Mitt. (Tschermak), 1903, vol. xxii, p. 103).

Tamanite = anapaite (Zeits. Kryst. Min., 1903, vol. xxxvii, p. 267).

Torrensite = rhodochrosite + rhodonite (A. Lacroix, Bull. Soc. franc. Min., 1900, vol. xxiii, p. 254).

Viellaurite = rhodochrosite + tephroite (A. Lacroix, ibid., 1900, vol. xxiii, p. 253).

Wapplerite = rösslerite (A. de Schulten, ibid., 1903, vol. xxvi, p. 99).

Warrenite = jamesonite (L. J. Spencer, Nature, 1904, vol. lxix, p. 575).

EDITORIAL COMMENT.

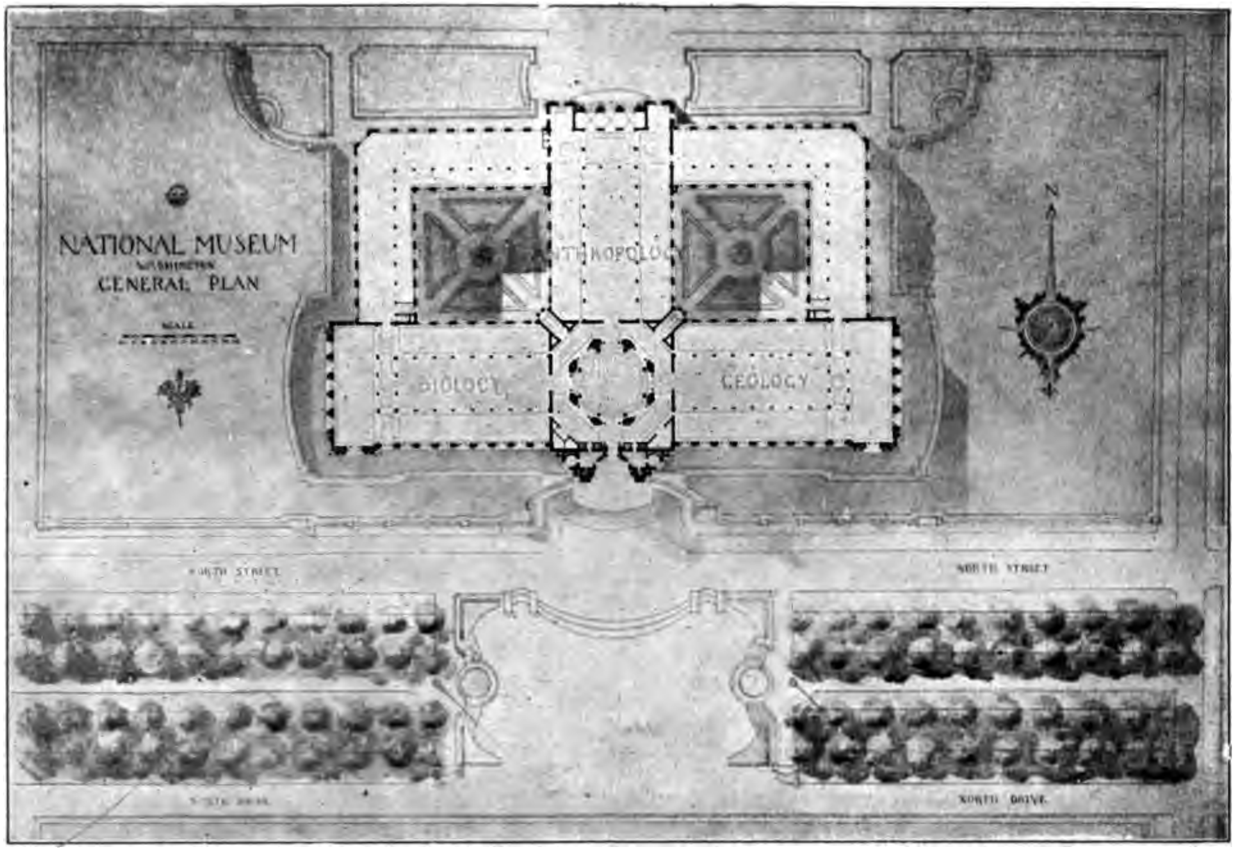
The New Building for the National Museum, at Washington, D. C.

PLATE XVIII.

The present National Museum building has, almost from the day of its completion, been recognized as quite inadequate to meet the requirements of the rapidly growing collections and to supply the needs of an ever increasing force of workers. In his report for 1882 professor Baird discussed this matter and proposed that a third building be erected on the southwest corner of the Smithsonian reservation, sufficient for the accommodation of the Geological Survey and the geological and mineralogical collections of the Museum. A bill providing for such a building was introduced into Congress and referred to the Committee on Public Buildings and Grounds, but no definite action at that time was taken.

From 1882 until the present time the necessity for a new building has never ceased to be the subject of more or less attention by the regents and secretary, but it was not until the spring of 1903 that a bill was finally passed appropriating three and a half million dollars for this object. At the present writing the foundation for the new building is laid and work upon the superstructure begun.

According to the details, as given in the last report of assistant secretary Rathbun, the new building, which is to be situated on the north side of the Smithsonian grounds and facing the old Smithsonian building, will have a length of five hundred and fifty-one feet, a width of three hundred and eighteen feet, exclusive of projections, and a hight of stonework above the basement floor of seventy-seven feet. There will be four stories including the basement, which, beginning above the level of the adjoining street, will be


NATIONAL MUSEUM
WASHINGTON
GENERAL PLAN
SCALE
N
ANTHROPOLOGY
BIOLOGY
GEOLOGY
NORTH STREET
NORTH STREET
NORTH DRIVE

well lighted and entirely available for use. The main and second stories will contain the exhibition collections, while the basement and upper story will be allotted to the many other requirements of a large museum.

In a general way it may be said that the building will consist primarily of a main part in the shape of a broad T, comprising three wide wings or sections diverging at right angles from a large rotunda at the southern or principal entrance. Ranges of narrower width, one on each side and two at the north, will connect the three ends of the T or main sections so as to inclose two large open courts (each 128 feet square), and thus complete the quadrangle. The two south sections, which, with the rotunda, comprise the front part of the building, will project slightly at each end beyond the walls of the side ranges.

The new structure will be located on the north side of the Mall, in the so-called Smithsonian park, about midway between Ninth and Twelfth streets, directly in front of the Smithsonian building, and with its center, like that of the latter, on the axis of Tenth street. While the main front and entrance will face southward, or toward the middle of the park, there will also be a commodious entrance by way of the basement on the north, as an approach from Tenth street. The northern facade will be about 78 feet from the sidewalk of B street north, while the central projection thereof, containing the entrance, will reach about 25 feet nearer to the street.

As the land rises rapidly southward from B street, it has been planned to have the basement floor slightly above the level of that street, but at the south the top of the basement will be nearly on a level with the ground. Suitable embankments will be built along the sides of the building, inclosing a broad area, which will also extend along the south front, thus making the basement equivalent to a full story for at least workroom, laboratory, storage, and heating purposes. Its hight will be 14 feet.

The first and second stories, intended for the public, will be 20 feet and 19 feet 5 inches high, respectively. The windows will measure 14 feet 9 inches high in the first and 12 feet high in the second, the corresponding ones in the

two stories occupying the same embrasure, though separated by ornamental metal work. These windows will be about 11½ feet wide, and the intervening wall space about 7 feet wide, giving a unit for the installation of exhibits of 18 feet 6 inches.

The third story will be 12 feet in hight, with windows about 7 feet high by 5 feet 3 inches wide, furnishing ample light for all the requirements of the laboratories and storerooms. In the three main sections of the building there will be another low story above the third story suitable for the storage of dried specimens.

The relatively small amount appropriated for this large building has demanded simplicity of design and the omission of all extravagant decoration. The lines and proportions have been so well planned, however, that the structure cannot fail to be one of great dignity and beauty and a worthy addition to the public buildings in Washington. The granite will be laid in ashlar courses, but the entrances will be worked up with a certain amount of elaborateness. A metal dome, with skylight, will cover the rotunda, and there will also be skylights along the main roofs for lighting the large halls.

The rotunda at the south, or main, entrance will be about one hundred and sixteen feet square, and lighted entirely from above. It will connect directly with the three great halls, which are to be similar in character and of the same length and width, about 209 by 116 feet, all provided with galleries except at the inner ends adjoining the rotunda. The galleries along the sides will be 32 feet wide, leaving interspaces of 50 feet width. This central or open part of each main hall will be 148 feet long and reach to ceiling lights under the skylights, a distance of 60 feet, while the galleries and sides of the first story will receive their light from the large windows of the fronts and courts. The galleries of the second and third floors are intended to be entirely screened off from the central halls and treated as space that can be divided to suit the requirements. The space under the galleries may be treated in the same way or left open, as circumstances may dictate.

The remainder of the building, consisting of the ranges

on the east, west, and north, will be 55 feet in interior width and have solid floors, one above the othe, the light being obtained entirely from windows.

The main and second floors will, as before stated, be used wholly for the public exhibition collections, while the upper floor will be divided into laboratories and storage rooms for the reserve collections. The basement will have the same dimensions as the first floor, but under the main halls it will require to be lighted artificially. The side areas will be of sufficient width for teams, which may enter the building at both ends of the south front. One of the south wings of the basement will be utilized for the boilers, power plant, mechanical workshops, etc.; the other, as well as the ranges, probably for laboratories and for the storage of such specimens as can best be accommodated there, though some parts of the ranges may be used for exhibition purposes.

The northern entrance will be by way of the basement, into a large vestibule with elevators and stairways. There will also be passageways leading in all three directions, the central one communicating directly with a small lecture hall occupying the center of the middle section of the basement. On each side of this hall will be a series of small rooms, some of which can be used for committee meetings.

The net floor area of the building will be about 411,374 square feet, or about 9.44 acres, subdivided as follows: Basement and main floors, each about 116,732 square feet; second and third floors, each about 88,955 square feet.

The building thus described will, as shown by the floor plan (plate xxviii), be occupied by the three departments of anthropology, biology, and geology. As the space occupied by the department of geology in the present building falls a little short of 20,000 square feet, it will be seen that the new structure will offer ample opportunity for expansion.

A few words may be added relative to the materials from which the building is to be constructed. As is well known, there has been a decided preference manifested of late by architects for light-colored material—a preference which, naturally, could be fully satisfied only by the adoption of marble. By many, however, it is felt that

marble is too delicate a material for the exterior of structures in the trying climate of the eastern United States.

Fortunately for those interested in the new Museum building, there has been developed recently a quarry of a very light muscovite-bearing granite at Bethel, Vermont, and it is to contractors controlling this quarry that the award for the first two stories above the basement of the new structure has been given. This stone when in the quarry weathers to a whiteness almost equal to that of marble, but with a softer and more mellow tint, and has, at the same time, the appearance of strength and massiveness of granite.

The basement story of the building is to be constructed of a light-pink granite from Milford, Mass., and the upper portion of a light-gray stone from Mount Airy, North Carolina.

G. P. M.

Notes on Goldfield, Nevada.

The following notes are based upon an examination of a few days, only, and are not presented as in any way an exhaustive report upon the district.

The Goldfield district is situated about twenty-five (25) miles south from Tonopah, near the boundary line between Nye and Esmeralda counties, Nevada.

The first discoveries of gold ore were made in the spring of 1903. The first rich ore was taken out early in 1904; and during that year, there was produced high grade ore ($100.00 per ton or more) to the value of about $2,200,000 net smelter returns. This ore was taken out mostly by leasers, hauled by team to Tonopah and shipped from there over a narrow gauge railroad. The chief producers during 1904 were

The Jumbo.........	Production	about	$700,000.00
The Florence	"	"	650,000.00
The Combination ..	"	"	600,000.00
The January	"	"	187,000.00

These properties are all near the south end of Columbia mountain. Other properties in the district have produced very rich ore, the "Sandstorm" for example, which lies north of the mountain, and from which a shipment of about

fourteen tons produced over $45,000.00 net. Rich strikes have been made at other points, notably at the "Quartzite," some five miles southeast of Columbia mountain, and at the "Simmerone" which lies between the two. No such regular and well defined ledges of ore have been found in the outlying portions of the camp as upon the properties near Columbia mountain; but the development work has not yet been prosecuted to the same depth.

The discoveries thus far made are scattered over an area some five or six miles square. This area was formerly covered by lava, the erosion of which has laid bare the rocks and veins and has formed a plateau or mesa which bounds the district on the west. The siliceous reefs of quartz and rhyolyte appear in irregular ridges of no great hight, marking the croppings of some of the veins. The rocks are much iron-stained, but are not very deeply oxidized.

Undecomposed sulphide minerals can be seen in the ore almost upon the surface upon the Jumbo, January and Florence. The ground water is met at the depth of about 200 feet from surface and below this level the ore is base although free gold is abundant. The ground is "heavy" below water level, and will require timbering and filling making the mining cost heavy in that desert country. Fuel also is expensive; and pumping and hoisting costs will be above the average.

The rocks of the district are andesytes, basalts and rhyolytes with some aplyte and silicified limestone. The andesyte is very soft; and shafts are easily sunk in it. The rhyolyte is much harder, and usually constitutes the ore. It contains much chalcedonic silica, evidently deposited by hot waters; but not much normal vein quartz. The dikes of rhyolyte are of all sizes from a few inches to forty feet in thickness; and have irregular strikes and dips with many branches and ramifications, both on the surface and in depth. They are so numerous and so frequently auriferous and so variable in position that there will certainly arise a great many conflicts and much litigation in the future. Several instances were noticed of opportunities for such trouble already fully developed.

The strike of the auriferous dikes is generally northerly

and southerly and there is a tendency toward an easterly dip which is quite variable. At times, however, the strike is curved and the veins are almost crescent-shaped. At other times, the deposits appear to be limited in depth and confined to pockets of very rich ore on the surface of the ground. This mode of occurrence together with the chalcedonic silica and the very fine condition of the gold even in the bonanza ore, added to the rotted appearance of the rocks all indicate deposition by hot spring action, and make it certain that the rich ore bodies are irregular in shape and extent and that they may often be expected to occur in chimneys and shoots of roughly cylindrical form, rather than in well defined veins continuously and uniformly mineralized. At the same time, there are abundant evidences of movement, and of mineralization along fissures and dikes in some of the principal mines near Columbia mountain. Thus in the Florence there are stopes some 200 feet deep, 200 feet long, and from six to fifteen feet between walls which are marked by clay selvage, planes of movement, drag pebbles and all the indications of strong fissures. Similar indications of extensive shattering are seen in the January and Jumbo; and may be developed in depth on other properties where not visible in the surface workings.

The oxidized ore at Goldfield is valuable solely for gold. Silver is almost wholly absent, as are lead and copper. Pyrite particles are visible in the harder portions of the quartz. Below the water level the ore contains gray copper, bismuthinite (bismuth sulphide) and some tellurides. The gray copper is rich in gold. One assay of a sample from the Florence mine at the depth of 250 feet gave seventy ounces of gold and seven ounces of silver. The ore from this level of the Florence all carries copper and will average possibly two per cent, while the first class ore contains about seven per cent. The bismuthinite is generally associated with rich ore in which the native gold is seen sprinkled all through the rock in intimate relation with the brilliant needles of the bismuth mineral. Free gold was not noticed in the gray copper.

There is abundant evidence of secondary enrichment in the shape of films, rich deposits in cracks and crevices

and in the spongy nature of the gold. But the general structure and the presence of very rich sulphide ore containing antimony, arsenic, tellurium and copper are all indicative of the existence of rich ore, probably in very irregular deposits, but that may be followed to a considerable depth. In other words, the ore is not all superficial and secondary. There will certainly be found ore shoots extending downward for many hundred feet.

The expense of prospecting such irregular lodes and the cost of mining and treating such complex ore in treacherous ground lead to the conclusion that low grade ore will never have a value in Goldfield; but that the assay value must be from fifteen to twenty dollars per ton to furnish any profit.

My opinion on the whole is very favorable; and I look to see a large production of gold for many years to come from the Goldfield district. H. V. W.

Butte, Montana, May 15, 1905.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Effect of Cliff Erosion on form of Contact Surfaces. By N. M FENNEMAN (Bulletin Geol. Soc. Amer., vol. 16, pp. 205-214.)

This is a suggestive paper in a somewhat new field of observation and theory. The problem was encountered in an investigation by Mr. Fenneman, of the contact relations of the Wyoming Red beds with the underlying granite of the Front range of the Rocky mountains. The field of study was the southern half of the Boulder and the northern part of the Denver quadrangles.

In this area the sandstones were evidently laid down on a submarine land surface of considerable relief, but the details of the relief were quite unlike the forms produced by stream erosion and the granite at the contact surface is as free from the products of weathering as the rock many feet below the contact.

Mr. Fenneman points out that the surface of contact between unconformable formations will, of course, have some dependence upon the topography of the preexisting land surface. The surface of contact is visible only in section; if this section is a straight line, the surface is presumably a plane. The more the line deviates from straightness, folding aside, the more rugged is the topography which may be inferred.

But these inferences fail to take into consideration the important change in topography which may accompany the advance of the sea.

There are two factors which will control the surface of contact, namely: (1) subaerial erosion, (2) marine erosion. These factors may combine in any proportion, of which there are two hypothetical extremes: (1) rapid subsidence and minimum wave-erosion leaving the subaerial topography unaltered. (2) slow subsidence and the complete dominance of shore erosion destroying the relief of the submarine land surface.

Neither of these extremes is considered by Mr. Fenneman. Of all possible relations between rate of subsidence and of wave erosion Mr. Fenneman discusses three hypothetical cases.

(1) Cliff-recession due to wave erosion more rapid than shifting of coast-line due to submergences; in this case a gentler seaward inclination than that of the slope produced by subaerial erosion would result, or if the original slope is broken by valleys and ridges the latter will be truncated. Whether this truncation reaches the valley bottoms will depend upon the rate of subsidence. Cliff recession will take place against accumulating difficulties due to increasing hight and length of cliff and absence of bays.

Case 2. Cliff recession progressively retarded until its rate equals that of the shifting of the shoreline due to submergence; In this case, at first a gentler seaward slope than that produced by subaerial erosion would be formed as in case 1. Then, when the rate of recession equaled that of shifting, the slope of marine denudation would be equal to the slope of subaerial condition and the receding cliff will have a constant hight. This hight will be such as to allow recession at the same rate at which the shoreline would move landward by submergence alone.

The land surface will thus be pared down uniformly. The denudation may or may not cut below the valleys of subaerial erosion. If it does cut below the valley bottoms the entire surface of contact will be fresh rock. If the paring is not below the valley bottoms, the weathered rock of the valley bottoms will be preserved on the lower side of the contact surface, while the rock surface of the cut planes which replace the ridges will be fresh and the sediments laid down upon it, derived from cliff cutting and active streams will be coarse and fresh.

These two facts distinguish this case from the advance of the sea without cliff cutting over a peneplain with its mantle-rock of fine material and its deeply weathered underlying rock.

Mr. Fenneman applies this case to the area studied: The Archaean-Wyoming contact has, he states, a maximum relief of perhaps 500 feet. Its undulations are extremely smooth, no slope being less than 3 miles long and the maximum steepness 150 feet to the mile. These slopes are unbroken by valleys, and the Archaean rocks, as stated earlier, are of uniform freshness. These

facts indicate that the entire surface of subaerial erosion on the Archaean rocks including the valley bottoms was pared by the Wyoming sea at least to a depth below the zone of weathering. This denudation erased the minor features of relief and reduced the major features.

The contact of the Archaean granite and the Wyoming Red beds illustrates then that phase of case 2 in which marine erosion has cut beneath the valley bottoms of the subsiding surface of subaerial erosion.

Case 3. Cliff erosion less rapid than shore line shifting by submergence. Hypothetically the surface of marine denudation would in this case have a steeper slope than that of subaerial erosion. This is manifestly impossible unless an initial cliff is assumed. The case then becomes a later stage of a process begun under the conditions of Case 1 or Case 2. Assuming the development of such cliffs the surface of marine erosion will slope seaward intersecting first the deeper and then the shallower valleys.

The principles illustrated by these three cases may be successively operative in controlling the contour of a single land surface, that is, the three cases given above represent conditions which obtain at different stages of cliff recession and shore line migration. If low initial cliffs, which are of common occurrence, be assumed, then cliff recession will be more rapid than shifting of the shore line due to subsidence, and the contour will be controlled by marine erosion (Case 1). The convex curve of subaerial erosion will be altered to a curve which is concave upwards. With the progressive decrease in the rate of cliff cutting, due to their increasing hight there will arrive a stage in which conditions obtain similar to that of case 2, i. e., when cliff erosion will just equal the shore-shifting due to subsidence, and the contour curve will be at a lower level than the preexisting contour of subaerial erosion, but similar and parallel to it. Subsequently cliff-recession will become less rapid than shore-shifting and the conditions are similar to those of case 3. The curve of marine erosion becomes curved upward and will approach but never quite coincide with the curve of subaerial erosion.

If the subsiding remnant of land be an undissected plain, it will be reduced by cliff cutting at an increasingly rapid rate as the hight of the cliffs grows less. If the subsiding remnant be dissected by valleys, islands will result from submergence, which will each reproduce the story of the entire land-mass.

If instead of low initial cliffs, well developed cliffs, cut while the land is stationary, be assumed, that stage of the process represented by case 1 will be omitted, otherwise the history of cliff-cutting and shore-shifting will remain the same as that given above.

In this abstract the reviewer has followed more or less closely Mr. Fenneman's language, which is extremely concise so much so

as to occasionally lose something in clearness. Four diagrams furnish graphic illustrations of the principles presented.

The discussion has an immediate bearing upon the inferences that may be drawn from contact surfaces, of the character of former land surfaces and ably calls attention to a factor which has been more or less overlooked, in making such inferences. F B.

Geologic Map of the Tully Quadrangle [New York]; Bulletin N. Y. State Museum 82, 1905; JOHN M. CLARKE and D. DANA LUTHER.

The New York State Museum has recently published two bulletins containing descriptions of the formations found on three quadrangles of that state accompanied by geologic maps. Bulletin 81, in which the formations of the Watkins and Elmira quadrangles in southern central New York were described and mapped, was reviewed in the AMERICAN GEOLOGIST last November.

The Tully quadrangle is located in central New York directly south of the Syracuse quadrangle in the third district of the original survey, which was described by Vanuxem in his final report of 1842. A comparison of these maps with the state one of 1842, shows at a glance the great development in our knowledge of the geology of New York state during the last 60 years. The quadrangle is easily reached from Syracuse and on this account it will be of special interest to the students of geology in that city and its University.

The rocks shown upon the may belong to the Upper Silurian and Devonian systems which the authors have represented by 18 divisions and grouped them as follows:

Neodevonic	Senecan	Ithaca sandstone and shale
		Sherburne flags
		Genesee shale
		Tully limestone.
Mesodevonic	Erian	Moscow shale
		Ludlowville shale
		Skaneateles shale and limestone
		Cardiff shale
		Marcellus shale.
	Ulsterian	Agoniatite limestone
		Onondaga limestone.
Paleodevonic	Oriskanian	Oriskany sandstone
	Helderbergian	Helderberg limestone.
Siluric or Ontaric	Cayugan	Manlius limestone
		Rondout waterlime
		Cobleskill dolomyte
		Bertie waterlime
		Camillus shale.

In the description of the units of sedimentation the lithologic

characters are clearly defined and lists of the more characteristic fossils given.

Probably that part of the bulletin which will prove of most general interest is the article by Dr. John M. Clarke on the "Ithaca fauna of central New York." In the following quotation Dr. Clarke has very clearly stated the relations of this fauna to contemporaneous faunas east and west, the misapprehension that existed for many years regarding its stratigraphic position and its gradual change from essentially a Hamilton fauna in the earlier deposits of the Ithaca formation to one more nearly related to the Chemung in the later deposits of the formation:

"Portage time and sedimentation in New York involved very marked geographic distinctions; at the east was, during its earliest stage, a marine fauna quickly followed by a lagoon deposition known as the Oneonta sandstone. Continuous with these beds through Chenango, Cortland and Tompkins counties are the true Ithaca beds carrying the littoral marine fauna here set forth; these beds being interleaved with the Oneonta deposits eastward and the true Portage or Naples beds westward. The latter contain an invading and deeper water fauna having nothing in common with that of the Ithaca beds. * * * *

Till 10 or 12 years ago a singular and deplorable misapprehension of the significance of the Ithaca fauna prevailed and was inadvertently countenanced in some of the volumes of the *Paleontology of New York*. Its fossils, lying well above the horizon of the Hamilton shales of central New York were in many instances described as of the Hamilton fauna, and it is to the work of Prof. C. S. Prosser that we owe the first rectification of these errors and the return to Vanuxem's original conception of the place of the Ithaca fauna. * * * *

It has been well recognized and often referred to in the published papers of professor Prosser and the writer that this fauna is at first a repetitive occurrence of the Hamilton fauna beneath, shades of difference in the species above and below the horizon of the Tully limestone and Genesee shale and Sherburne sandstone being at first absent or obscure, but becoming more pronounced upward in the series and accompanied by the introduction of species alien to the fauna below. Broadly it may be said that the fauna starting at the base of the Ithaca sedimentation is essentially Hamilton but by degrees, by the addition of species and through mutational and profounder variation from the ancestral species, puts on a different aspect and gradually assumes that of the higher or Chemung fauna."

At the close of this article is given a "list of localities of Ithaca fossils" from Cortland, Chenango, Broome and Otsego counties, together with a list of the species found at the various localities.

The geologic maps of the several quadrangles so far published by the New York State Museum are models of cartographical skill

probaly, as yet, unexcelled. The field work for the Tully quadrangle and others in central and western New York has been done or directed by Mr. Luther. This work merits the praise which it has received from the state geologist who says that Mr. Luther's "skill in the careful stratigraphic determination of the older rocks in New York is in my judgment not to be surpassed." C. S.

Oklahoma Geological Survey (Dept Geol. and Nat. Hist.), 3d Biennial Report, A. H. VAN VLEET, Territorial Geologist, Guthrie, 1904, pp. 49.

The third biennial report of the territorial geologist of Oklahoma contains five papers concerning Oklahoma geology: Preliminary report on the contact of the Permian and Pennsylvanian in Oklahoma, by C. T. Kirk; Geology of the Wichita mountains of Oklahoma, by C. N. Gould; Present status of the mining industries of Oklahoma, by E. G. Woodruff; Report of mineral deposits in the Wichita mountains (a list of localities from which samples have been collected), by Edwin DeBarr; A preliminary report on the building stone of Oklahoma, by Eck Frank Schramm.

Mr Kirk's paper, though a "preliminary" one, is of more than passing importance to stratigraphic geologists. Here we have a description of the passing of the lowest Permian limestone, the Wreford limestone, or its equivalent, nearly across Oklahoma. Gould has noted the southern ending of the Marion and Wellington formations in northern Oklahoma where the limestones seem to disappear and merge into "Red-beds."* Kirk describes the Wreford limestone of Kansas as being replaced by two coalescing layers of sandstone, which he calls the Payne, and traces the sandstone as far south as Norman, Oklahoma.

On jage 9 in his paper occurs a section in which the sandstone representing the Pawhuska limestone of Adams, (correlation probably taken from Bulletin 211 of the U. S. Survey) and the Payne sandstone occur in a 29 foot section of sandstones. In Kansas these formations are separated by about 700 feet of limestone and shales. Of this amount nearly 100 feet, including the limiting layers, is of limestone. Here in the Cimarron valley this section is represented by three layers of sandstone, two, six and eight feet thick respectively, and one of fifteen feet. These figures when taken in connection with Adams' statements, published in various places, that there is no unconformity gives a peculiar result. While this is not at all impossible when the geology of the surrounding region is considered, yet it opens up some very important points both paleontologic and stratigraphic, particularly so, when it is remembered that these sandstones are supposed to be typical "Red-beds" and are an "encroachment to the eastward of the line of red coloration" without unconformity. However, Kirk suggests that "When

* Trans. Kans. Acad. Sci. xvii, pp. 179-181.

a general survey of this region is made the formation below and above may be correlated and defined accurately as to local dips, 'pinchings out' and other evidences of small unconformities."

The remaining papers deal briefly with the geologic and economic resources of the territory as represented by their titles.

J. W. B.

Some Crystalline Rocks of the San Gabriel Mountains, California. By RALPH ARNOLD and A. M. STRONG. (Bull. of the Geol. Soc. of America, vol. 16, pp. 183-204, April 13, 1905.)

This paper, by two students of the Leland Stanford Jr. University, owes its interest in part to the location of the field of investigation. This is in a region of magnificent scenery, accessible from Los Angeles and Pasadena, well known to tourists and but scantily investigated by geologists. It offers to petrographers a new and rich field of investigation. The results of preliminary petrographic study are presented in this paper.

The San Gabriel mountains comprising an area of approximately 1,200 square miles and located in southwestern California, extend 60 miles southeast from the junction of the Sierra Nevada and the Coast range. The range is dissected by streams flowing east and west and is divided by the San Gabriel river into a southern portion with steep slopes and a northern range with more gentle slopes which grade into the Mojave desert.

The geologic investigation of this region was made without topographic maps and the rocks described were collected on reconnaissance trips.

A brief review of the previous literature on the region is given showing that there has been considerable divergence of opinion as to the age of the range. It has been called Primitive, post-Jurassic and post-Cretaceous. The presence of tilted lower Eocene sandstone and shale on the northern flanks of the range has led the writers to place the greater part of the elevation in late Eocene or Oligocene time.

The petrography of the rocks of the San Gabriel mountains is given in some detail. The rocks are both igneous and metamorphic and comprise biotite-granite, quartz-monzanyte, grano-dioryte, hornblendyte, aplyte, micro-pegmatyte, quartz-hornblend-porphyryte, diabase-porphyry, hornblende-dioryte-gneisses, biotite-granite-gneisses, hornblende-schists and garnetiferous-schists. Analyses are given of the grano-dioryte which is the most abundant rock type of this region as well as of the Sierra Nevada of California. The term grano-dioryte is used as defined by Lindgren: a rock in which lime-soda feldspars predominate and which consists of quartz, oligoclase or andesine or both, or orthoclase, hornblende and biotite, with accessory titanite, zircon magnetite and apatite. Calculating the norm from analyses of the grano-diorytes, the reviewer finds the rock to be a biotitic-hornblende grano-aderose that is the rock is

dosalic, perpelic, domalkalic and dosodic, differing in order, range and subrange from Lindgren's grano-dioryte. A comparison of the grano-diorytes of the two ranges shows them to be very similar. There is a central mass of coarse grained acid rocks bordered on the south by finer grained grano-diorytes, gneisses and quartz-monzanyte. Hornblende dykes are not numerous but alpytes cut the rocks of the entire region. The metamorphic rocks are abundant in the southern part of the range. A. J.

Maryland Geological Survey; Miocene. WILLIAM B. CLARK, State Geologist. Text, pages clv, 543, with nine plates; and volume of plates, x-cxxxv. 1904.

These two sumptuous volumes give us the most complete account in existence of the Miocene deposits and fossils of Maryland. The introduction and account of the general stratigraphic relations was written by the State Geologist, Dr. Wm. B. Clark. The account of the geological and paleontological relations, with a review of earlier investigations, is contributed by Dr. George B. Shattuck who has devoted much time to the field study of its stratigraphy. His comparative taxonomic table shows at a glance the evolution of the classification and correlation of the Maryland Miocene from the alluvial (in part) of Maclure in 1809 to that of Shattuck in 1902, who divides the Maryland Miocene into three formations, which in ascending order are the Calvert, Choptauk and St. Mary's. As a result of the careful study of the fossils the three formations have been divided into 24 zones. This part of the work closes with a series of sections, mainly along Chesapeake bay, and an extensive table giving the geological range and geographical distribution of all the species listed.

The relations of the Maryland Miocene to that of other regions and to the recent fauna are discussed by Dr. W. H. Dall. The State Geologist reports that "This chapter is by far the most important contribution to the interpretation of the Maryland Miocene deposits which has been hitherto made and shows in a highly philosophical manner the relationship of the Maryland Miocene fauna to that of other regions and to the recent fauna." Dr. Dall concludes that "In a general way, allowing for local peculiarities, the Miocene fauna of North Germany compares well and agrees closely with that of Maryland, while the Mediterranean Miocene finds a closer analogue in the more tropical fauna of the Duplin beds of the Carolinas." This chapter closes with a list of the characteristic species of the North American Miocene. In explanation of this list Dr. Dall states that "By characteristic are meant the species which occur only in the Miocene, and occur in it from top to bottom. * * * It is not meant that they occur at every horizon or zone, but that they have existed throughout the Miocene somewhere, and disappear with the inauguration of the Pliocene."

The Systematic Paleontology has been prepared by different

authors and many of them are recognized authorities in the subjects which they have discussed. The total number of fossil species described is stated to be 652. The mammals, birds and reptiles are described by Case of Milwaukee; the fishes by Eastman of Cambridge: the ostracods, bryozoans and hydrozoans by Ulrich and Bassler of Washington; the corals by Vaughan of Washington; the foraminifers by Bagg of Springfield; and the plants by Hollick of New York and Boyer of Philadelphia. The remaining chapters were prepared by members of the Maryland Survey, the lamellibranchs by Glenn, now of Nashville; the other molluscs, the brachiopods, the worms, the radiolarians, and most of the crustaceans, by Martin, now of Washington, and the echinoderms by Clark. The report is illustrated by a map showing the distribution of the Miocene deposits in Maryland, a chart of columnar sections, seven plates giving excellent views of Miocene sections and 126 plates of fossils. The beautiful and accurate drawings of the fossils are largely the work of the late Dr. J. C. McConnell, whose early death is a severe loss to American paleontology.

Finally, it is worthy of note that in this age of commercialism the Maryland Geological Survey, like that of New York, still stands for scientific scholarship and the real advancement of the science. Its volumes, written or edited in the halls of Johns Hopkins university, bring to the reader the spirit of research which pervades that institution, and, like it, stand for what is best in scientific scholarship. In closing I desire to quote and endorse the last paragraph of professor Schuchert's review of this work. He says: "These volumes should be in the hands not only of stratigraphers and paleontologists, but of all teachers of historical geology as well, for here is given not only a detailed description of the Maryland Miocene stratigraphy and its preserved organic remains, but also the relationship of these faunas to those of other areas of North America and of Europe. The State of Maryland is to be congratulated on its able and active survey staff, under the efficient leadership of Professor W. B. Clark. Among state surveys it stands second, ranking next to that of the rich state of New York."* C. S. P.

The Origin of Certain Place Names in the United States (Second Edition). By Henry Gannett. U. S. Geol. Survey, Bulletin No. 258. Pages 334. Washington, 1905.

This edition has 54 pages more than the first edition, which was published three years ago. Much local history, from the aborigines and the pioneer white settlers, is contained in our geographic names; and the list might be greatly increased, so that these names and their derivations and meaning for any one of the large and old states would fill a large volume. W. U.

* Am. Jour. Science, 4th Ser., vol. xix, March, 1905, p. 259.

The Second Biennial Report of the Director of the Agricultural College Survey of North Dakota. DANIEL E. WILLIARD. Director. Pages xii, 187; with 36 plates (maps, sections, and views from photographs). Bismarck, N. D., 1904.

In connection with a large amount of topographic and geologic work in this state by the U. S. Geological Survey, an important examination of its soils and agricultural capabilities is being carried forward by the State Agricultural College, as here reported. Professor Willard acknowledges great indebtedness to his predecessor, the late Prof. Charles M. Hall, of whom a brief biographic sketch is reprinted from the AMERICAN GEOLOGIST of April, 1902. Two posthumous papers by Prof. Hall treat of the history of Lake Agassiz and the drainage of the southeast part of the state; and several papers, mostly on soil surveys and water supply by artesian and common wells, are presented by Prof. Willard and his assistants.

North Dakota has great diversity of soils, from the very fertile Red river valley plain, the bed of the glacial Lake Agassiz, to the boulder-strewn knolls and hills of the Coteau du Missouri, and the Bad Lands of the Little Missouri river, the last being unsurpassed in irregularity and picturesqueness of contour. W. U.

Casselton-Fargo Folio, North Dakota and Minnesota, No. 117, Geologic Atlas of the United States. By CHARLES M. HALL and DANIEL E. WILLIARD. Pages 6, with 6 map sheets. Washington, 1905.

About a quarter part of the tract here mapped and described is in Minnesota, wholly in the area of Lake Agassiz; and the part in North Dakota extends northwest a few miles beyond this lacustrine area. The lake beds and glacial drift are underlain by Cretaceous strata, which yield slightly saline and alkaline artesian water, and these rest on granite, as shown by sections of very deep wells; but the bed rocks older than the drift have no outcrop in this district. W. U.

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ADAMS, GEO. I.

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Water resources of the Middlesboro-Harlan region of southeastern Kentucky, (Wat. Sup. Irr. Pap., No. 110, pp. 177-179, 1905.)

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BRANNER, J. C.

Natural Mounds, or "hog-wallows." (Science, vol. 21, p. 514, Mar. 31, 1905.)

BROOKS, A. H. (and others).

Report on progress of investigations of the mineral resources of Alaska in 1904, U. S. G. S., Bull. 259, pp. 196, 1905, pls. 3.

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The glaciation of Mount Orford. (Ott. Nat., vol. 19, p. 52, May, 1905.)

CHAMBERLIN, R. T.

The Glacial Features of the St. Croix Dalles Region. (Jour. Geol. vol. 13, pp. 238-257, Apr.-May, 1905.)

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Water resources of the Curwensville, Patton, Ebensburg, and Barnesboro quadrangles, Pennsylvania. (Wat. Sup. Irr. Pap., No. 110, pp. 159-163, 1905.)

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Report of the state paleontologist, 1903, pp. 396, pls. 29, 1905.

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Percé, a brief sketch of its geology. (Rep. N. Y. State paleontologist, 1903, pp. 134-173, 1905.)

CLARKE, JOHN M. (and D. D. LUTHER).

Geologic map of the Tully quadrangle. (Bull. N. Y. State Museum, No. 82, pp. 35-70, map, 1905.)

CLARKE, JOHN M.

Geology of the Watkins and Elmira quadrangles. Bull. 81, New York Museum, pp. 29, May, 1905.

COLLIER, A. J.

Recent development of Alaskan tin deposits. (U. S. G. S., Bull. 259, pp. 120-127, 1905.)

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CUMMINGS, WM. N.

The Hostotipaquillo District, Jalisco. (Eng. Min. Jour., vol. 79, p. 942, May 18, 1905.)

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Water resources of the Fort Ticonderoga quadrangle, Vermont and New York. (Wat. Sup. & Irr. Pap., No. 110, pp. 126-129, 1905.)

DARTON, N. H.

Preliminary report on the geology and underground water resources of the central great plains. U. S. G. S., Prof. Pap., No. 32, pp. 433, pls. 72, 1905.

DARTON, N. H.

The Zuni Salt Lake. (Jour. Geol. vol. 13, pp. 185-194, Apr.-May, 1905.)

DILLER, J. S.

Bragdon formation. (Am. Jour. Sci., vol. 19, pp. 379-388, May, 1905.)

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Subterranean fishes. (Science, vol. 21, p. 516, Mar. 31, 1905.)

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The Clinton Hematite. (Eng. Min. Jour., vol. 79, p. 897, May 11, 1905.)

FENNEMAN, N. M.

Effect of Cliff Erosion on Form of Contact Surfaces. (Bull. G. S. A., vol. 16, pp. 205-214, April, 1905.)

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Benjamin West Frazier [Portrait]. (Am. Geol., vol. 35, p. 263, May, 1905.)

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Record of deep well drilling for 1904. U. S. G. S., Bull. No. 264, pp. 106, 1905.

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Contributions to the Hydrology of the Eastern United States. (U. S. G. S., Wat. Sup. & Irr. Pap. No. 110, pp. 211, pls. 5, 1904.)

FULLER, M. L.

Notes on the hydrology of Cuba. (Wat. Sup. Irr. Pap. No. 110, pp. 183-199, 1905.)

FULLER, M. L.

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Bibliographic review and index of papers relating to underground waters published by the United States Geological Survey 1879-1904, Wat. Sup. & Irr. Pap., No. 120, pp. 128, 1905.

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Water resources of Cowee and Pisgah quadrangles, North Carolina. (Wat. Sup. & Irr. Pap., No. 110, pp. 174-176, 1905.

GOLDTHWAITE, J. W.

The Sand Plains of Glacial Lake Sudbury. (Bull. Mus. Com. Zool. vol. 42, Geol. Ser. vol. 6, pp. 263-301, pls. 5, May, 1905.)

HARTNAGEL, C. A.

Notes on the Siluric or Ontaric section of eastern New York. (Rep. N. Y. State paleontologist, 1903, pp. 342-359, 1903.)

HESS, F. L. (See PRINDLE, L. M.)

HOBBS, W. H.

Origin of the channels surrounding Manhattan Island, New York. (Bull. G. S. A., vol. 16, pp. 151-182, Apr., 1905.)

HUDSON, G. H.

Contributions to the fauna of the Chazy limestone on Valcour island, Lake Champlain. (Rep. N. Y. State paleontologist, 1903, pp. 270-296, 1905.)

JOHNSON, D. W.

The Tertiary History of the Tennessee river. (Jour. Geol. vol. 13, pp. 194-232, Apr.-May, 1905.)

LA FORGE, L.

Water resources of central and southwestern highlands of New Jersey. (Wat. Sup. & Irr. Pap., No. 110, pp. 140-155, 1905.)

LAKES, ARTHUR.

The Occidental and other Coal Mines of Heurfano County, Colorado. A description of the Geology and Development of the Region. (Mines and Minerals, vol. 25, p. 473, May, 1905.)

LEITH, C. K.

A summary of lake Superior geology with special reference to recent studies of the iron-bearing series. (Trans. Am. Int. Min. Eng., Lake Superior meeting, Sept., 1904.)

CORRESPONDENCE.

American Association for the Advancement of Science, Summer Meeting of Section E.—Section E of the American Association for the Advancement of Science will hold a summer meeting at Syracuse, New York, July 19, 20, 21, 22. Arrangements have been made for making the meeting enjoyable and profitable to all members of the Section. The vicinity of Syracuse is one of great interest in several branches of geology: the fossiliferous rocks of the New York series are well exposed in many ravines; the surface shows most of the phenomena of chief interest in Glacial geology; the pre-Glacial and the modern topography have been worked out by specialists, and the economic geology of the district is important. The chief study in the field during the meeting will be the gorges and lakes of the Glacial drainage, which are the most novel feature of the district.

In making its plans for the meeting the sectional committee had accepted the cordial invitation of the committee having in charge the joint summer courses in geology for several eastern universities and colleges to hold a meeting in conjunction with the summer school. The following programme may now be provisionally announced:

Wednesday, July 19, 8.00 P. M.—The Section will meet informally for the purpose of organization and of listening to short addresses by the officers of the Section, the state geologist and others. Professor T. C. Hopkins, of Syracuse University, will discuss the local geology.

Thursday, July 20. —Field day with picnic lunch. The Section will visit the Jamesville lakes, the "fossil cataracts" and the several Glacial stream channels in the vicinity of Jamesville and part of the shore line of lake Iroquois in Onondaga valley. Field addresses will be given by professor H. L. Fairchild on "The Local Glacial Features" and by professor John M. Clarke on "The New York Series, with a special reference to the Paleontology and Stratigraphy of the Syracuse district."

8:00 P. M.—Popular illustrated lecture by professor H. L. Fairchild on "Glaciation in North America, with Particular Reference to the Effects of the Ice Sheet in Central New York.

9:30 P. M.—Social meeting in the rooms of the University Club.

Friday, July 21.—Field day with picnic lunch. The party will go by trolley to Fayetteville and thence on foot to the Glacial channels and lakes south and west of Fayetteville. Field addresses by Mr. Frank B. Taylor, "The Great Lakes in Their Relation to Local Geology," and by others.

8:00 P. M.—Business meeting of the Section for the reading and discussion of papers.

Saturday, July 22.—To Fayetteville by trolley or by boat on

the Erie canal. Visit the Fayetteville channel, Round and White lakes, the Mycena and adjacent channel northeast of Fayetteville, Salina shales, Manlius limestone, Helderberg limestone, Oriskany sandstone and Onondaga limestone outcrops. Field address by professor A. W. Grabau on "The Physical Characters and History of Some New York Formations."

Free discussions of all papers will be invited. Further particulars regarding the meeting may be obtained by addressing professor T. C. Hopkins, University, Syracuse, New York, or the undersigned.

EDMUND OTIS HOVEY,
Secretary Section E,
Am. Assoc. Adv. Sci.

American Museum of Natural History,
New York, May 23, 1905.

PERSONAL AND SCIENTIFIC NEWS.

AT WILLIAMS COLLEGE, Mr. Hirdman L. Clelland has been appointed professor of geology.

PROF. A. P. BRIGHAM OF COLGATE UNIVERSITY, HAMILTON, N. Y., expects to spend the summer in Europe, sailing June 14. His address will be: Care of Bowen, Shipley & Co., 123 Pall Mall, s. w., London.

DR. E. W. HILGARD, of the University of California has been given leave of absence for one year, and then will return on two-thirds pay at 73 years of age. He is engaged on a work in agriculture, soils, etc.

GEOLOGICAL SOCIETY OF WASHINGTON.—At the meeting of May 10 the following named papers were read, viz.: Coal testing work at St. Louis, *E. W Parker;* The Ocoee, *C. W. Hayes* and *David White;* Fresh water marl of Alaska, *W. H Dall.*

DR. U. S. GRANT, will spend the summer in Alaska, in the employ of the United States Geological Survey, in one of the parties under the general charge of Dr. A. H. Brooks, leaving Evanston about June 1. His headquarters and post-office address will be Valdez, and his work will be in and about the copper mines of the region of Prince Williams sound.

WILLIAM B. BARBER, a young geologist and engineer of great promise, died at his native place, Alameda, California, of typhoid fever, May 4, 1905. He was a graduate of Stanford University, 1902. A well considered and able paper of his appeared in the AMERICAN GEOLOGIST a year ago (vol. 33, p. 335) on the "Lamprophyres and associated igneous

rocks of the Rossland mining district, British Columbia," and another, in which E. H. Nutter was joint author, appeared in the Journal of Geology the same year (vol. 10, p. 738) entitled "On some glaucophane and associated schists in the Coast ranges of California."

THE 35TH ANNUAL MEETING of the American Institute of Mining Engineers was held in Washington, May 2d to 5th, inclusive, with 125 registered members in attendance. The list of papers to be presented included 52 titles. Of papers actually read, those of Mr. A. C. Spencer on Magmatic Vein Waters in Alaska, and professor J. F. Kemp on the Copper Deposits of San Jose, Tamaulipas, Mexico, were of greatest geological interest, though several very promising numbers were omitted through lack of time.

Excursions were given down the Potomac to the gun-testing grounds at Indian Head, followed by a planked-shad dinner at Marshall Hall, and to the gold mines on the Potomac above Washington.

THE UNIVERSITY OF TEXAS MINERAL SURVEY is temporarily suspended, owing to the withdrawal of its support by the late legislature of the state. The office is closed and all work abruptly brought to an end. Two excellent reports are left unpublished, though partly printed, one of them accompanied by a detailed map of a portion of west Texas, bordering on the east side of the Rio Grande del Norte, including portions of Brewster, Presidio, Jeff. Davis and El Paso counties. This map must have cost the state considerable money, and the three geologists who executed the fieldwork (W. B. Phillips, B. F. Hill and J. A. Udden) a large amount of hard work. Its legend shows not only the formations: Post-Cretaceous, Late Upper Cretaceous, Upper Cretaceous, Lower Cretaceous, Jurassic, Carboniferous and Older Paleozoic, and Pre-Carboniferous, but also igneous dikes and sills, localities of quicksilver, Coal, Silver and lead, Intrusives, lavas and tuffs, Granite and syenyte, and Dioryte.

This default by the legislature entails a serious loss upon the state and an injustice upon the geologists who did the work. We know nothing of the causes that produced this unfortunate result, but we are reminded that republics are sometimes suicidal as well as ungrateful.

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W

ERRATA FOR VOLUME XXXIV.

On page 63, line 6, for "Out" read Aus.

On page 195, line 7, for "Bragau" read Grabau.

On page 317, line 10, for "and of lake" Pepin read end of lake Pepin.

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ERRATA, VOL. XXXVI.

Page 320, line 6, for "comparisons" read companions.
Page 332, line 4 from the bottom, for "62" read 26.

C. L. Herrick

THE

AMERICAN GEOLOGIST.

VOL. XXXVI. JULY, 1905. No. 1.

CLARENCE LUTHER HERRICK.

By W. G. TIGHT, Albuquerque, New Mex.

PORTRAIT, PLATE I.

When a great and good man is taken from the midst of his life work and those whom he has served are called upon to realize their loss, there is ever a desire to perpetuate his memory and to preserve such knowledge concerning him as will be of further service to humanity. In preparing a fit memorial to Dr. Herrick the writer realizes his own inability to do justice to the man and his work. Perhaps no other outside of his immediate family was better acquainted with him than myself. Having lived with him in the home, in the camp, in the school room and laboratory and being in almost constant correspondence with him for a long term of years when circumstances separated us, his death is a very deep personal loss. Dr. Herrick has many pupils scattered over the world who feel that they owe much to him and in whom he took a very deep interest and pride. Of this large number there were two boys who were a little nearer to Dr. Herrick's heart than any of the others. Not because they were any better or brighter but because of the circumstances connected with their coming together. These two were Herbert L. Jones and myself. When Dr. Herrick went to Denison university in 1885 and started his career as a teacher he was a comparatively young man, being only twenty-seven years old, but his characteristic earnestness and enthusiasm were so manifest that he attracted to himself out of a graduating class of thirteen these two boys and through his influenee both remained at Denison for a year of post-graduate work. We were the first resident

post-graduate students Denison ever had. Prof. Jones devoted his life to the study of Botany, contributing several important articles to science. He taught science in the preparatory department of his Alma Mater for several years, was assistant botanist at Harvard for a time, resigning to accept the professorship of Botany at Oberlin college, where he served but one year, when called from his labors by Death, at the very opening of his career. It was because we two boys were first on his long list of devoted pupils that we were held with special regard by him. Yet in spite of the intimacy of my relations with him through all these years that have intervened it is with misgiving that I undertake the sad task of presenting this tribute to his life and character.

In order that my views may not be colored too much by my own personal feeling and sense of personal appreciation it is my purpose to express myself largely through the words of others and to present such views as have been given by them as will in my judgment bring out the salient features of Dr. Herrick's life and work. In a letter written to Rev. J. L. Cheney, Cleveland, Ohio, Sept. 27, 1904, his brother C. J. Herrick says: "His was a life very difficult for any one person to estimate, for his work was in so diverse fields that few men have even a speaking acquaintance with all of them. His life may be roughly divided into four periods. Very early in his career he seems to have laid out at least in a rough way a rather ambitious plan of action including for the first part of his life miscellaneous research and study in the broad field of general natural history—a general broad foundation. Then was to follow a period of intense specialization in the circumscribed field of zoological work leading up to a mastery of anatomy, and physiological and comparative psychology on the basis of the mechanism of the nervous system and to the philosophical correlation. So far as I am aware my brother never announced this or any other program, and I doubt if such a thing was ever definitely formulated even in his own mind; yet from some of his conversations which I remember years ago I believe that some such plan was in his mind. While the four periods referred to above were marked by extraneous events.

apparently artificial or arbitrary, yet I think it may be said that the ideal scheme was in the end fairly achieved, though with great deviation in the details of the working."

FIRST PERIOD. 1858-1884.

The son of a Baptist clergyman, Dr. Herrick was born near Minneapolis, Minn., June 21, 1858. He grew up in a home far from neighbors as a solitary child with few playmates and very early showed his bent for the study of nature. While still in the Minneapolis high school he collected extensively and left at graduation a case of over a hundred mounted bird skins and other specimens in the high school. It was during this period that his father got him an eight dollar microscope. With this crude instrument and without library facilities he worked over the fresh water fauna of the neighboring brooks and pools so thoroughly that before graduating from the university of Minnesota, in 1880, he had published several articles of value on the fresh water crustacea of Minnesota and four years after graduation, with somewhat better facilities, published a report on the microcrustacea of Minnesota which is still standard. These years and those of his university course were filled with many bitter struggles, not the least of which was with poverty and the lack of materials for study. But notwithstanding these, he completed his course in three years, at the same time partly supporting himself by assisting on the Minnesota natural history survey. He had also showed so obvious a native gift with his pencil that upon his graduation the president of the university said that he was uncertain whether to advise him to devote his life to science or art. But there was no uncertainty in the mind of the young man. Continuing his work with the geological and natural history survey of Minnesota after graduation, he published many papers in rapid succession on the fauna of the state and began an extensive report, the first volume of which was completed in 1885. This was a large quarto on the mammals of the state fully illustrated with many colored plates and pen drawings. It was accepted for publication, but for lack of funds in the survey, never saw the light. Years afterward, in 1892, a small octavo was published by

the survey made up of the more popular parts of this work. He spent a year in Leipzig at the University during 1881-'82. And in 1883 he was married to Miss Alice Keith, of Minneapolis.

He took his Masters and Doctors degree from the university of Minnesota.

SECOND PERIOD. 1884-1889.

Called to the chair of Geology and Natural History of Denison university, Granville, Ohio, in the summer of 1884, he spent the fall of that year at Denison, then returned to Minneapolis to complete the work begun by him on the Minnesota survey and in the fall of 1885 moved with his family to Denison. It had been his intention to continue his zoological work there, and there was great activity in this line during the entire period, but the routine excursions made as a part of the instruction of his geology classes showed him so much of interest in the local strata that his chief labors while in Granville, were upon the fossils and stratigraphy of the Waverly free stones and shales of Ohio. This work was abruptly cut short by his removal from Granville in 1889, and while never rounded out as he would have liked is probably his most important geological work. In 1885 he founded the Bulletin of the Scientific Laboratories of Denison university, in which the greater part of his researches and those of his pupils on Ohio geology were published.

His phenomenal success as a teacher during this and subsequent periods was due to factors some of which are easily seen—others hard to define. After his attractive personal qualities and magnetic enthusiasm I should place his deep philosophical insight and the fearless way in which he opened up his profoundest thinking to even his most elementary pupils. The ability to do this without befogging the air was an exceedingly rare gift and was stimulating to even a dullard. He knew the philosophical classics thoroughly from original sources and the trend of his thinking was very early foreshadowed in the translation of Lotze's Outlines of Psychology, published in 1885 in Minneapolis, with its appended chapters on the nervous system.

THIRD PERIOD. 1889-1894.

Upon his acceptance of the chair of Biology in the university of Cincinnati in 1889, the geological studies with which the preceding five years had been so fully occupied were summarily brought to a close and he threw himself with renewed energy into the study of the nervous system. Extensive papers on the brains of different animals appeared in rapid succession of which the most valuable are two series, one on the brains of various fishes, the other on those of reptiles. In 1891 the Journal of Comparative Neurology was founded and served as the medium of publication for most of these researches. The founding of this journal can best be designated as a piece of characteristic audacity. It was a purely private enterprise with no funds assured and very little outside co-operation promised. But without counting the cost he plunged boldly in, expecting a constituency to be developed as the work went on. In this he has not been disappointed wholly, though recognition of financial needs has lagged sadly behind that of the scientific excellence of the journal. At the close of 1891 he resigned his chair in the university of Cincinnati to accept a chair of Biology in the university of Chicago, then being reorganized. The early part of 1892 was spent in Europe, chiefly in Berlin. Upon his return the adjustment at Chicago presented unexpected difficulties and after a series of misunderstandings he withdrew from the institution, declining an offer to return to Germany for further study on full salary. He was immediately elected to his old post in Denison university with an assistant and the privilege of devoting only a part of his time to teaching, the remainder to be spent either at home or abroad in the further prosecution of his research. A year and a half of great productiveness followed. He bought a small tract of land adjacent to the college campus, built a residence upon it and planned to devote the remainder of his days to breeding animals on an extensive scale and studying the laws of heredity, comparative psychology and allied problems. But before this project was fully under way his health broke down and he was forced to abandon his home in the fight for life.

In December, 1893, he had a severe attack of la grippe,

but as was his custom in illness went on with his work as usual. Upon completion of the last examination of the term he came home too ill to correct the papers, and in the course of the following night was attacked by a severe hemorrhage from the lungs and for weeks his life hung in the balance. With the return of spring his strength increased sufficiently to enable him to remove to New Mexico, where the local physicians told him he had a fighting chance for a few years. He accepted the challenge bravely and for more than ten years held the disease in check. During the spring of 1894, the college dedicated the Barney Science Hall, which had been built largely under the stimulus of his presence in the faculty, but he was never permitted to work in it.

FOURTH PERIOD. 1894-1904.

This decade, filled with bodily pain and the worse torture of anxiety and mental unrest, is yet one of the most productive periods of his life. Much of the time was spent in the open with covered wagon and camp kit, and with the return of strength scientific interests again absorbed his attention. Naturally in this case he again turns to geology and an extensive series of articles on the geology of New Mexico, bears testimony to the industry of these apparently aimless wanderings. The first scientific work done in the territory was a revision of his earliest important work, the Crustacea of Minnesota. As soon as his geological knowledge became known his services were in demand as a mining expert and during the later years of his life in the territory he supported his family chiefly by practising this profession as strength permitted. For four years he was the president of the territorial university at Albuquerque, though at the close of the third year it became evident that the strain of the executive work and confinement were too hard for him, and his connection during the fourth year was mainly of supervision and general control. During his last year there was an obvious failing of physical strength so that long field trips had to be abandoned. But the more quiet life gave opportunity for a thorough recasting of many questions and formulation of matters which had been in his

mind all his life. So that before his death much of the philosophical correlation of which mention was made in his early life, was effected. A number of articles have already been published in the philosophical serials bearing on these matters and there is a considerable collection of MSS. remaining, much of which can doubtless be edited for publication. It is gratifying to know that he had the satisfaction of seeing this work so well rounded out before his death and that the later months of his life wete much more restful than those preceding, some of which were marked by extreme suffering.

He continued in about his usual health until Sept. 8, 1904, when he again had a series of uncontrollable hemorrhages, daily becoming weaker until on the morning of the 15th, he peacefully passed away.

His life work having been distributed in three widely separated communities, each gave expression of its estimate of the man at the time of his death.

The university of Minnesota knew him directly as a student and young investigator and his friends there have watched his subsequent career.

The Minnesota Magazine for October, 1904, contains the following notice:

"University men and women will regret to hear of the death of Prof. C. L. Herrick, at Socorro, New Mexico, September fifteenth. Mr. Herrick was graduated from the university, and had here been granted the degree of Doctor of Philosophy. Specializing in ornithology, he mounted many of the specimens now in the Biological Museum, and made scientific reports one of which was published for the state by the geological and natural history survey; and another an illustrated treatise on Fresh Water Crustaceans, ranks high among American authorities.

"As professor of Natural History in Denison university, his activities widened. He established the Journal of Neurology, one of the leading scientific periodicals of the world. He gave much attention to the geology of Ohio, and was for some time associate editor of the AMERICAN GEOLOGIST, to which journal he made extensive contributions.

"The university of Chicago offered him a professorship,

the duties of which he never assumed. Ill health compelled him to seek the more favorable climate of New Mexico, where after a short service as instructor in the school of mines at Socorro, he was elected president of the university of New Mexico, at Albuquerque. Here his zeal and energy so inspired his associates that the university entered upon an era of activity unusual in so young an institution. His health, however, continuing to fail, Dr. Herrick was forced to resign the responsibilities of the presidency and seek the more active outdoor work of a practical geologist and irrigation engineer. So employed and continuing to contribute to the scientific journals, he labored industriously until his death. His last paper appears in the current number of the AMERICAN GEOLOGIST.

"Few alumni of the university of Minnesota have attained higher rank among the American scientists. Three commonwealths feel the influence of his versatile brain; three universities honor his memory. For years he labored under the discouragements of disease, but he held out gallantly in the prosecution of his chosen work. All his intellectual life was given to the abstruse problems of science, and his achievements should place him among the savants of the opening century."

In Ohio "The Granville Times" and "The Denisonian" the weekly college paper, both published portraits and extended articles concerning him and his life work.

The Denison Scientific Association held a special memorial service at which Prof. G. F. McKibben of Denison, Prof. A. D. Cole of Ohio state university and Prof. Aug. F. Foerste of Dayton, Ohio, made the principal addresses.

Prof. Cole said in part in his address on "C. L. Herrick as a Maker of Scientific Men," published in a special memorial volume of the Bulletin of the Scientific Laboratories of Denison university.

"I desire to emphasize especially his rare power of influencing young men—and that too without seeming to make any effort to do so—to adopt his own point of view of life and devote themselves, wholly or in part, to the quest of truth which was to him the great thing in life. This seems to me to be the most striking and characteristic

thing in professor Herrick's personality. He was learned, but we have known others learned too; he was devoted to his work but such devotion, though uncommon, we may find elsewhere; he was a rare teacher, but the country has many great teachers; he was a man of strong religious faith and rich Christian life, but that too we may parallel in other lives. But I cannot think of one other man who so powerfully impressed those with whom he came into any sort of contact with a real longing to find out new truth by their own effort and add it to the legacy of knowledge which the present generation has inherited from the past. His own work as an investigator was great; his work as a maker and trainer of investigators was perhaps greater. I have never known an enthusiasm so contagious as his. It is no mere accident that both his brothers, his wife's brother, his only son and a large proportion of his students have caught the spirit of original research and made important contributions to the fund of new knowledge. Contact with him in class room, laboratory or household seemed equally efficient for propagating the germ of personal investigation. He might have been a great teacher even without this power, as others have been; with it his success was assured and eminence certain with favorable conditions. * * * What were some of the reasons for the unquestionable power he possessed of moulding the purposes and lives of his associates?

Let us note at least a few of them. One reason for this power was undoubtedly the perfect sincerity of his devotion to science. It was so apparent from even a slight acquaintance with him that he loved it and believed in it as a pursuit worthy not only of his own highest thought and most earnest effort, but deserving as well the supreme attention of any man. He was not given to proselyting; there was no direct appeal to others to interest themselves in those things which he pursued. But given a noble mind, despising the shams which it already sees constitute so large a part of modern life, longing vaguely to realize its youthful dreams of mental achievement and moral victory, in close daily contact with an enthusiasm so pure and unselfish as that of professor Herrick, is it any wonder that the ambition to

emulate him should be kindled in that mind? We all know the teacher, who seems to teach for "what there is in it for himself"—such small return of money, social position or reputation as seems to be attached to his business; we have seen how he bolsters up his own dead interest in the progress of science by sounding phrases about the dignity of scientific pursuits. No one recognizes the sham more quickly or completely than the students in his class room, and with the recognition his power as teacher is gone. No one can interest another in an intellectual problem in which he himself is not genuinely interested. Even if he believes himself interested, that is not enough; self-deception cannot save him. His students will feel—vaguely perhaps, but surely—that the interest is not real. On the other hand the teacher with a genuine zeal for his subject, so simple that it never feels the need of self- assertion, already has his battle two-thirds won. The student unconsciously detects the real article as well as the sham. As it is hopeless to deceive students by the parade of simulated enthusiasm, so it is unnecessary to proclaim the real one. Thus professor Herrick's intellectual honesty and genuine zeal for science found an answering note in the minds and hearts of all those whose lives touched his. We who knew him felt our own ambitions purified and ennobled by the contact.

Secondly, his remarkable industry emphasized the effect of his sincere devotion to science. He was not one to tell how much midnight oil he burned or in any way indicate the intensity of his labors, but both their quality and quantity compelled our attention and we watched and found that he rarely spent an idle minute. Not only were his working hours long, but intensely active. Many of us remember the long quick stride which carried him so rapidly from task to task: it was an index to the energy of the mental machine within.

A letter recently received from a former student who was for a time a member of his household says: "The tireless energy of the man was inspiring. His light was last to go out in the home and on going to breakfast early in the morning it was no unusual thing to meet professor Herrick returning from the woods or swamp with a supply of

material for the day's classes * * * If he ever took a rest we never knew of it."

A third reason for professor Herrick's ability to instill the spirit of research was found in his subordination of most of the common aims which move men to what was evidently the great aim of his life. * * * Professor Herrick, while remarkably faithful to all of his duties to others, managed to give such emphasis to his scientific labors that it became but natural to think of him always as a man-of-science.

Another thing that attracted students and led them unconsciously to seek to imitate him was the freshness and originality of his ideas. His mind was always taking conventional and commonplace ideas and making something fresh and new out of them. He thought much of the philosophical bearing of scientific things. "The Psychological Basis of Feelings," "Psychological Corollaries of Modern Neurological Discoveries" are two of the many titles of his scientific papers indicating his tendency to philosophize the results of his scientific observations.

Besides the four mental traits which I have mentioned in attempting to account for the power he possessed of energizing others into scientific activity there were moral attributes which contributed more to the same end.

One of these was connected with his originality and mental independence, namely his courage in over-riding false traditions and calmly undertaking the solution of difficult problems. His was the pioneer type of mind. And so he frequently introduced novel methods in his teaching which aroused attention and interest. Although his connection with Denison was not a long one, he introduced at least four striking innovations which have already stood the test of years and bid fair to be permanent. These were (in chronological order) The Scientific Association, the Bulletin of the Scientific Laboratories, The Neurological Journal, and the courses of study which lead to the degree of Bachelor of Science at Denison.

At the time of its introduction each one of these innovations seemed to be a questionable proposition, hardly likely to succeed. * * * He started the first volume of the

Bulletin of the Scientific Laboratories the year following his coming to Denison. * * * There are eighty-five articles written by many different authors, most of them Denison men, students or faculty members, and not a few of them those who have become original workers through the influence and example of professor Herrick himself.

Undoubtedly its success has been due to the fine start it made through the unremitting labors of professor Herrick as editor. Of the 26 articles which constitute the first four volumes issued under his editorship, no less than ten were from his own pen. And after ill health compelled him to seek another climate, and in spite of the fact that he had taken the editorship of the Journal of Comparative Neurology upon his hands we find him a frequent and valuable contributor. So late as June 1900 (in Vol. XI.) we find an elaborate article of more than sixty pages, with a map and 34 beautiful plates for which he was so well known. * * * In 1887 professor Herrick founded the Denison Scientific Association whose object, aim and history during seventeen years are well known to most of you. Very faithfully has it carried out its aims as he expressed them in its constitution "To collect, record and disseminate information bearing on the sciences and to stimulate interest in local natural history and preserve specimens illustrating the same." I think very few of those who tried to help him start the Association expected that it would continue and develop as it has done. My own feeling concerning it is well expressed in a letter recently received from another of its charter members, professor J. E. Woodland of the Rochester Athenaeum and Mechanics Institute. He says:

"I recall vividly the organization of the Denison Scientific Association and the enthusiasm with which professor Herrick directed the work and gathered the material for the programs. I have been associated with other Scientific Associations since then but have yet to find the genuine local interest and enthusiasm that characterized the one in Granville."

The fourth innovation due principally to professor Herrick, was the complete revision of the work in science in the course of study leading to the B. S. degree

at Denison. * * * It was another case where professor Herrick's independence of tradition led to important results for Denison.

A sixth reason for professor Herrick's ability to arouse the spirit of scientific research in others we find in the breadth of his interests and sympathies. He did not follow the fashion of extreme specialization so characteristic of our time. Before he came to Denison he was state mammalogist of Minnesota, at Granville he was botanist, zoologist, geologist and neurologist, not merely teaching but investigating along these lines. While in New Mexico he added work of a mining engineer to that of geologist and neurologist, and in his last months we hear of his resuming study and writing along philosophical lines, a labor which had been begun many years before. And so under his tutelage we find one of his students inspired to become a botanist, another a biologist; several became geologists and others neurologists. And to all he was able to extend such counsel, stimulus and sympathy that his influence became one of the determining forces of their lives

And this brings us to the last reason that I will name to explain professor Herrick's power over his students; namely, his personal interest in them, not alone in their scientific development, but in all their joys and troubles. Quoting again from Mr. Woodland's letter, "To the student he was never a professor with awe-inspiring dignity, but rather a companion and friend. * * * There seemed to be some great pressure incessantly driving him to work, yet with it all we never entered his room that he did not make us feel entirely welcome. * * * He never spoke a word of discouragement to any one."

And now in conclusion let me illustrate several of these sources of professor Herrick's power to inspire students by reading to you a letter which I received to-day from W. E. Castle, now professor of zoology in Harvard university, one of the many young men who honor professor Herrick's memory in the highest possible way, by following in his foot-steps.

"While in conversation with a zoologist from a distant state I was asked from what college I came. 'From a col-

lege' I replied 'of which very likely you never hea son.'

"'O yes,' was the prompt reply, 'I know Deni Herricks have made Denison famous.'" This incid evidence of the high regard in which the scientific gun at Denison by professor C. L. Herrick is hel workers elsewhere in similar lines.

From an article in the same Bulletin by H. He den we quote: Of professor Herrick's contribu philosophy a word should be said. That his intere deep and abiding one is abundantly evident from at his writings which include many articles and di dating from the publication in 1882 of his trans Lotze's lectures on psychology to the series of ar "Dynamic Realism" which he had begun to publi Journal of Philosophy, Psychology, and Scientific at the time of his death. He made frequent short tions to the Psychological Review, besides publish ous other articles of a psychological and philosophi acter in his own journal. His interest in problems and religion is evidenced by diverse articles in certa religious periodicals as well as much unpublishe script.

Of his metaphysical writings it should be said were always inspired by his scientific researches. was satisfied with the easy philosophy of the "a physical" standpoint of many fellow scientists. physical parallelism he regarded as "the Great Ba aim of his life was to throw light upon just such so- soluble problems as the relation of consciousnes brain.

"Ignorabimus" is a word which never fell from The unity of the material and the mental is a tr which he came to lay increasing stress in his lat Starting from a Lotzean spiritualistic idealism he n hold of the monism which characterizes that philo world-view, though in many respects he worked it, his scientific studies serving to correct any ten an exclusive emphasis upon the mental. This is the title under which his latest writings appear—"

Realism"—in which many will find hints of a coming philosophic movement which is to reinterpret the fixed ontological categories of a past metaphysics in more dynamic and organic terms.

Of his contributions to the theory as to the nature of consciousness (equilibrium theory of consciousness), the physiological basis of the emotions, theory of pleasure-pain (summation-irradiation theory of pleasure-pain), his discussion of the reflex arc or organic circuit under the terms of his own coining ("aesthesodic" and "kinesodic") and in general his interpretation of experience in dynamic and energic terms, we may not here speak in detail. But the attention of the readers of this Bulletin should be called to this side of his work as it is embodied in his various published writings and especially in certain writings which are yet to appear."

In the memory of his pupils professor Herrick was greatest as teacher. This statement can only be appreciated by those who knew him personally and were in his classes. There was no display or oratory. He was not what would be called a gifted public speaker, though he was often called upon for such services. It was in the class room or about the seminar table or in general conversation that the inexhaustible fertility of his thought and fine suggestiveness of his language appeared. In his lectures one always knew that he was getting the best, the latest, the deepest results of his scientific research and philosophic reflection. Never was any work slighted in which his students were involved. Other things might be sacrificed—time, money, convenience, even health itself, but never the student. The result was that his teaching was not confined to the class-room or laboratory. There never was an occasion upon which he was not ready to suggest, advise, assist the groping mind in search for truth.

He was extraordinarily versatile in the class room. He would lecture with a piece of chalk in each hand, sketching at the same time ambidextrously upon the blackboard the figure he was describing. Never did the lecture degenerate into a mere description of the figure. The figure he was describing was the figure in his mind—the figure that he

was thereby suggesting to the student's mind. Such description and all the other instrumentalities of the classroom and laboratory were always kept in their proper place and proportion as means to the end of knowledge and insight. His artistic sense was too fine to allow them ever to degenerate into mere ends in themselves; the technique of his teaching was in itslf a work of art, the more that it was unconscious on his part. His courses in neurology, embryology, and histology were primarily courses in thinking. This is no doubt the reason why so many of his students look back upon his teaching as a period of their intellectual awakening."

One of his colleagues at Denison university says of him: "All who knew professor Herrick loved him. Different friends had different reasons for loving him, but all agreed in loving. Christian people loved him because he was a loyal Christian man. Intellectual people loved and admired him because of his brilliant and keen intellect; and men in general loved him because they saw in him a true and noble man loving the truth and living it out in his daily life."

As has been said of another: "He did his work with a quietness which concealed its power. He contributed to science our best example of the scientific temper. He was a profound thinker. He was a successful teacher. He was a lover, inspirer, and leader of youth."

Being so intimately acquainted with Dr. Herrick and his family it was my privilege to see many of the letters of sympathy and appreciation which were addressed to the bereaved wife and quotations are made from a few of them which refer directly to the characteristics of Dr. Herrick.

"* * * Dr. Herrick was a great man. Had his health been kept good through the last ten or more years his work and writings would have shown even more clearly the caliber of his mind, and the later years of his life would have been honored as few American scientists are honored.

"I count myself fortunate in having known him so well. As a youth he brought me at the university of Minnesota, some natural history specimens of his own preparation.

That resulted in his being employed on the survey, and in his working up some of our material. After his departure for Granville I only knew of him by his publications. But the fruition and the scientific acumen displayed in his writings fully bore out the estimate I formed when I first came to know him. He has left a beautiful and honorable record of which his children may be proud.

N. H. Winchell."

" * * * I cannot resist the desire of saying a word concerning Dr. Herrick's later years in New Mexico. When I went to the southwest it was Dr. Herrick's presence that drew me thither. For several years I knew him as my teacher in geology and biology, as an inspiring companion in camp and field and as a faithful friend and advisor in every emergency. He welcomed me not only into his classes but into his home as well; and I came to know him as the teacher, the student, and the man.

"His work in New Mexico formed the most splendid exhibition of what heroic courage and unfaltering will power can accomplish in the face of obstacles which are usually regarded as insurmountable. Broken in health, his body wasted by the disease to which he had fallen victim, he nevertheless worked on with tireless energy, accomplishing the impossible by sheer strength of will. Those who have not known of the conditions under which his work was accomplished can never realize all that it represents. They see the finished published report; but not the man rising from his bed, within an hour after a hemorrhage from the lungs, to tramp across the foot-hills to his work. They see the report of a geological reconnaissance; but not the writer struggling up a steep mountain slope, straining every nerve and muscle, until he feels the approach of another hemorrhage; dropping at last with exhaustion to wait for what he believes to be the end, and lying there on a hastily made bed, under a drifting snow, through a night so cold that all the provisions were frozen, but rising next morning to press on through one of the worst snow storms that ever swept the Manzana mountains. This I have seen and marveled that human endurance could last so long. And were the truth told about all the suffer-

ings on thirsty plains and storm-swept mountains, undergone by him who was not able to bear the least of them, that truth would seem almost incredible.

"Through it all there was an enthusiastic devotion to his work which inspired every one with whom Dr. Herrick came in touch. I believe his students will agree that he had a rare ability to enlist enthusiastic interest in everything he did. Whether in the class-room or around the camp fire his hearers were inspired with a new desire to know more about the wonderful truths of nature of which he talked. This essential quality of the successful teacher he had in the highest degree. * * * I wanted to say at least one word to you about him to whom I owe more than I can realize.

D. W. Johnson, Dept. of Geology.
Mass. Institute of Technology."

These few quotations will give an idea of the high esteem in which Dr. Herrick was held by those who came into personal contact with him. I know of no better word to express the general characteristic of the man than one which I have heard often used in reference to him, and which he has used often to me in reference to himself, and that is "pioneer." A pioneer in every sphere of his activity, it was his task to lay foundations among the difficulties. In material things he organized the first laboratories in Denison University in biology and geology. He was instrumental in the construction of the new science building "Barney Memorial Science Hall," yet he never was to work in its laboratories. When overtaken by sickness and it was known that he must leave Denison some of his "boys" went to his house with a closed carriage and took him to the Barney Science Hall and carried him through the fine laboratories he had so carefully planned, in their arms, and he remarked that he believed that he knew how Moses felt when he was permitted to view the promised land. The same thing was experienced at the university of New Mexico. He started his work there in a few meagre rooms, was instrumental in the erection of the Hadley Science Hall, but was not permitted to labor in its laboratories.

In the intellectual field it was the same way. His

studies and publications on the Waverly of Ohio, while extensive, were, as he says himself, only preliminary.

In the field of biology and philosophy it is the same. He has opened up the path and pointed the way for others to follow. Yet in spite of the great diversity of directions of his mental activity he has manifested the true pioneer instincts and his vision into the future development and possibilities of each field of study has been clear and certain.

I believe the surest test of greatness when applied to his life work will show that as time goes on his work will be more largely appreciated and his service to the cause of science and humanity will be more clearly recognized.

His devoted wife, one son grown to manhood and two daughters survive him; the latter all in school or college and far away at the time of his death. The funeral service in his home at Socorro was simple, just as he would have chosen, but on the following week, all departments of the university of New Mexico united in a most fitting memorial service at Albuquerque, where those who had known him intimately for years paid high tribute to his worth.

To have known the man was to love him. To have felt the power of his influence and earnest enthusiasm in his work was to have gained an inspiration for a life-time.

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THE ORTIZ MOUNTAINS.

THE HIGH ALTITUDE CONOPLAIN; A TOPOGRAPHIC FORM ILLUSTRATED IN THE ORTIZ MOUNTAINS.

BY IDA H OGILVIE, PH. D. ROCKLAND, ME.

PLATE II.

During the past winter the writer was engaged upon a somewhat detailed survey of the Ortiz mountains, New Mexico. These mountains are in the central part of the territory, some twenty-five miles east of Albuquerque, and somewhat farther southwest of Santa Fé. The region proved to be of unusual interest from the three separate points of view of physiography, petrography, and palæontology. A full report on all of these subjects will be published elsewhere, the present paper touching only upon certain physiographic points of general interest.

The Cordilleras of North America in Mexico and for one hundred or more miles north of Mexico, consist of many ranges. These ranges are various in length, hight and direction, but the general trend of the Cordilleras as a whole is N. W.—S. E. The ridges are generally steep and are separated by flat plateaus. The general surface of the plateau region is rarely less than 6,000 feet in altitude, although in some cases rivers have cut below the general level.

Near the 34th parallel the Cordilleran belt divides, one portion trending northward, to and beyond Colorado, the other portion running westward and then northward through Arizona and Nevada. These form respectively the Rocky mountains and the Basin ranges. Between them lie the great plateaus.

Bordering the Cordilleran country are many volcanic areas. The eruptions vary in age and in type, extending from shortly after the close of the Cretaceous to nearly recent time, and including volcanic cones, extrusive and intrusive sheets, dikes, necks and laccoliths. The volcanic region is confined to the borders of the Cordilleran belts.

The Ortiz mountains lie within this borderland, in the eastern branch, not many miles north of the point where the ranges fork. They are laccolithic in origin: post-Cretaceous and probably pre-Pliocene in age. West of the

Ortiz are the Sandia mountains, a range of the basin type whose steep western face marks a fault scarp with a throw of over 4,000 feet. On the east the Sandias have a gentle slope and the beds dip gently east. The gentle easterly dip persists for many miles, and across the edges of these dipping beds a plain has been cut. The plain is not perfectly flat but has irregularities due to two causes. One of these is the Rio Grande and its tributary, Galistro creek, which have begun to dissect the plain; the other the difference in hardness of the various rocks cut, the edges of hard beds standing up in cuesta-like scarps. The hardest beds in the region are igneous sheets, derived from the Ortiz mountains.

The Ortiz laccolith was intruded after the strata were tilted to the east. Its cover has been largely removed by erosion, and the tops of the central and highest mountains (whose altitude is a little short of 9,000 feet) consist of the igneous core. Across the edges of the surrounding strata a plain has been partly built and partly cut, this plain sloping away from the laccolith on all sides. Because of its outward slope in all directions this form is here named a conoplain, and its slope is partly cut and partly built. This conoplain becomes continuous below with the general level of the region, at an altitude of about 5,800 feet. The conoplain has been cut alike across the Cretacic beds and the igneous sheets, and upon its surface has been deposited alluvial material (the Santa Fé marl of Hayden). It is not to be understood that this plain is a smooth surface with the configuration of a cone; on the contrary the harder beds stand above the soft to the extent of upwards of a hundred feet. But a line drawn from the central mountains outwards in any direction will pass over a surface cut on the surrounding rocks and sloping upwards towards the mountains. It is confidently believed that such a form is the normal one in a mountainous arid region, differences of topographic age being marked by differences in slope.

The difference in altitude between the mountains and the surrounding plateau (a difference of about 4,000 feet) is sufficient to produce a marked difference in precipitation. Vegetation is the measure of precipitation. The mountains catch the rain, and are in consequence forest-covered, with

such types as Pinusponderosa (var. scapulorum), Quercus undulata, and various shrubs of the oak and holly families. Associated with these are the cactus-like types, Opuntia, Cereus and Yucca. The vegetation is thus, for an arid region, a considerable one. The surrounding plains present a marked contract; Opuntia, Cereus and Yucca, together with Artemisia (sage brush) form the prevailing types. The largest trees there are pinon and a small cedar.

The result of this difference in climate is that the mountain springs give rise to streams which disappear entirely a short distance from their source. Within the Ortiz area there is no permanent stream which finds its way to the sea. For the greater part of the year the arroyos are entirely dry, and many of the springs dry up also. But when rain comes, it comes in quantities, and a few days of storm will start raging torrents.

The details of the idea of the growth of river valleys and of cycles of erosion have been developed in regions of moderate climate and of equably distributed rainfall. It is evident that in such a region as the Ortiz the normal erosion cycle will be markedly different. Leaving aside for the moment the larger question of the origin of the great plateaus, and also the special case of the Ortiz mountains, let us consider the theoretical erosion history of an ideal laccolith.

If we imagine a symmetrical laccolith of homogeneous rock, to have arched up the strata of previously horizontal rocks, the initial stage of erosion may be compared to that of Prof. Salisbury's homogeneous, symmetrical island. But with this difference that in the case of the island the limit in down-cutting is a result of checked velocity and is at sea level; in the case of the laccolith the limit is formed by the point at which the streams disappear, and may be at any altitude.

The transporting power of a stream depends upon volume and velocity. An increase in volume increases the transporting power by more than a simple ratio; velocity depends upon volume and declivity; hence an increase in volume indirectly adds to the transporting power by increasing the velocity. And an increase in declivity aids the

transporting power by more than a simple ratio. These facts were brought out thirty years ago by Gilbert in his classic memoir on the Henry mountains.

The amount of corrasion which a stream can perform depends upon its load. The transported detritus forms the tool with which it cuts, but an excess of material prevents corrasion. When a stream has all the load it can carry, the entire energy is used in transportation, and there is none for corrasion. If there is an excess of detritus, the transporting power is insufficient and deposition takes place. When a stream empties into a body of standing water its velocity is checked, material is deposited and further corrasion is impossible.

The ordinary peneplain, of Powell's type, is produced as a result of checked velocity. On emptying into the sea a stream's velocity diminishes, it deposits material, and its valley widens by weathering. When several valleys widen at the expense of the interstream areas a flat is formed, and this gradually extends upstream, until a peneplain is produced. But the initial cause of these results is checked velocity and that alone.

The energy of a stream depends not only upon velocity but also upon volume. Obviously a decrease in volume would also lead to deposition and to a cessation of corrasion. Such a decrease in volume might take place in various ways; but the common way in the plateau region is when a stream in its course passes from a less arid to a more arid climate. In the case of our ideal laccolith the rain would all be caught near the summit, streams would become established which would flow down the slopes, and on reaching the arid surrounding plain these streams would speedily dry up. This result would be accomplished partly by evaporation and partly by soaking in, as a result of the lower ground water level.

In the case of the laccolith, the process is aided by lessened declivity. The form being a constructional one, pushed up out of a previously existing plain, there would be a change in grade in passing away from the slopes of the mountains. This decrease in declivity would produce a corresponding decrease in velocity. Hence lessened volume

and lessened velocity would work together to produce deposition at a point near the edge of the disturbed area.

If the rainfall were equably distributed the point of disappearance of streams would gradually move nearer the mountains as more material accumulated. The theoretical end of the cycle would come when the laccolith became so far reduced that it could no longer catch the moisture, and wind alone would carve its surface. This old age laccolith would in a general way resemble the mature island; it would have slight elevation, be carved by radial valleys, and would be surrounded by a cut plain sloping gently away on all sides, this in turn being surrounded by a built plain. The whole would be closely analogous to the sea level forms of peneplain grading seaward into stratified deposits.

But in the region under consideration this ideal cycle probably never took place, since it would normally be interfered with by the two factors, unequal annual distribution of rainfall and wind.

The effect of the unequal distribution of rainfall is analogous to that of an oscillating coast. Given a coast that is alternately rising and sinking, no peneplain will be produced. If an approximation towards it develops, a slight uplift will rejuvenate the streams causing them to incise steep-sided channels; a slight sinking will drown the streams and fill their channels with deposits.

Similar processes are normally going on in the degradation of a laccolith. The burning heat of summer pushes the point of disappearance nearer the mountains, and even most of the springs go dry. At some uncertain period in the fall or winter, rains come and then torrents rush down rapidly cutting through the previously formed alluvial deposits, redepositing them farther out on the plain. These mountain torrents often change their courses entirely from one season to the next, the course depending upon the more or less fortuitous arrangement of the surrounding alluvial material. Therefore the surrounding conoplain is deeply scarred with arroyos and there are more arroyos than are ever full at any one time. Hence in no stage of the actual erosion cycle is the conoplain absolutely flat. In all stages it will be cut by gullies, but surface inequalities will be largely obliterated by filling with alluvial deposits.

In the usual erosion cycle in a moist climate, deposition is a mark of increasing age. There are notable exceptions, but in the typical, normal case a flood-plain is formed after a considerable amount of down-cutting has been done at the mouth of the stream. In the laccolithic cycle deposition takes place at all stages and in all places except the uppermost slopes. For if, after a rain, a flood stream extends its course two miles onto the plain and there dries up, for the last mile and a half or so it will have been losing volume and velocity and will have been depositing its material either as a flood plain or as an alluvial fan. If a few days later it has shrunk in volume and extends only one mile onto the plain, its transporting power will have decreased throughout its length and deposition will be taking place at the edge of or within the mountains. As the stream continues to shrink, its transporting power decreases until material is dropped well within the mountains. This deposition of material is a normal feature of all stages of the erosion cycle, though obviously more material will have been deposited when old age is reached than in youth.

The form taken by the alluvial deposits is somewhat diffierent in the two climates. The general process of cut and fill is the same for both, but the surface configuration differs. An old valley emptying into the sea develops flood plains along its lower course and also a delta at its mouth. These deposits are laid down in standing or in slowly moving water.

The banks of the river are still higher than its channel and the flood plain is a sort of filling dropped into the bottom of a curve concave upwards. The laccolithic deposits are as a rule built up on a flat with no pre-existing valley, and they take the form of alluvial fans. The confluence of several fans from neighboring streams may produce a plain.

In the normal erosion cycle in a humid region the cross section of the valleys changes from a steep sided V in youth, to a gentler sloped U in maturity. In arid regions the U shape never comes. If the valleys widen, it is by the retreat of nearly vertical cliffs. The reason seems to be that moisture and its results, soil and vegetation, are at

a minimum, hence there are no causes to produce the softening prominent in an eastern landscape. And when water is present at all, it comes in sufficient bulk to produce a torrent of large volume and high velocity. Such a torrent anywhere would cut steep-sided canyons, provided only that the rock cut into is sufficiently hard to stand in cliffs. In many cases joints are present which cause the rock to break off in blocks leaving cliff faces. So in the erosion cycle of our laccolith, the plain will not only be scarred at all stages, but it will at all stages be cut by steep-sided canyons.

Another interference with the ideal cycle is the wind. No one who has seen the whirlwinds moving over the deserts of Sonora or Chihuahua can feel any doubt as to the great possibilities of wind as an erosive agent. The general effect of wind upon a region such as the one under consideration would be the removal of fine material, thereby lowering the plains, the scarring of the hard rock by mechanical abrasion, and the drying of the soil.

Such may be considered the normal factors of erosion, but the cycle in nature is usually interrupted, or has abnormal conditions at the start. Among the interruptions may be mentioned vulcanism, the presence of some large river flowing to the sea, and climatic changes. For if some river is near enough to be reached by the streams, the laccolith at once becomes a part of the drainage basin of that river and its cycle is limited by the level of the river, which in turn is limited by sea level. Variations in humidity would change the position of the point of disappearance, and damper epochs would produce rejuvenation.

The actual laccolith is rarely ideal, but usually consists of several different intrusions, not necessarily circular in outline, into strata not originally horizontal, the whole more or less disturbed by faulting. The Ortiz mountains are abnormal in all these respects. It is no part of the present paper to describe them, but only to point out the generalities of this process as exemplified in them.

If it is possible for a plain to be cut at high altitude in the case of a small and isolated laccolith, the question at once arises as to whether some similar process may not

have produced the broad areas of the great plateaus. It is difficult of demonstration, but the impression is very strong that these plains are not peneplains cut at sea level, but that they were produced at their present altitude by some process more or less analogous to the preceding.

Whatever the factors affecting the region as a whole, there seems no manner of doubt that the conoplain of the Ortiz has been produced in some such manner. There is no evidence whatever of the presence of any large lake or sea that could have afforded even a temporary baselevel for the cutting. Nor is there any evidence that the country has been reduced to a lower level than it has at present, since the Miocene. We are forced to the conclusion that the sloping plains surrounding mountain masses were cut at their present altitude, and that diminishing volume was the essential factor in the cutting.

GENETIC AND STRUCTURAL RELATIONS OF THE IGNEOUS ROCKS OF THE LOWER NEPONSET VALLEY, MASSACHUSETTS.*

By W. O. CROSBY, Boston, Mass.

INTRODUCTION.

The Lower Neponset valley, or more specifically, that part of the valley of the Neponset river within the limits of the Boston basin, properly embraces all that part of the Boston basin between the Blue hills, a denuded anticlinal axis dividing the Boston basin from the parallel and overlapping trough of Carboniferous sediments known as the Norfolk basin, and the broad band of conglomerate extending westward from Savin hill on Dorchester bay through Dorchester, Roxbury, West Roxbury, Brookline and Newton into Wellesley and Needham. This great belt of con-

* This paper is an advance presentation, in outline, of a portion of Part iv of the author's detailed and systematic study of the Geology of the Boston Basin in course of publication in the series of Occasional Papers of the Boston Society of Natural History. For the petrographic distinctions in this field the author is indebted to Dr. Florence Bascom, whose preliminary observations on the volcanics only have been published (Bull. Geol. Soc America. vol. 11, 115-126), and whose more complete and elaborate work on both the volcanics and plutonics awaits publication in connection with the forthcoming Part iv of the Boston Basin series.

glomerate, some three miles in normal breadth, is, structurally, one simple, flat-topped and somewhat unsymmetrical anticline, the central and dominant arch of the Boston basin (the Shawmut anticline), separated from the Blue hills or southern highlands by the Lower Neponset valley, and from the northern highlands by the Lower Charles valley, each of these main lateral valleys exhibiting, in the general view, a synclinal structure, with slate as the prevailing surface formation, but being, withal, as complex in geological structure as the central ridge or water-parting is simple. As thus defined, the Lower Neponset valley is, west of Boston harbor, a rectangular area some three miles wide and eight to ten miles long, including, on the mainland, small portions of the towns of Canton and Dedham, the whole of Hyde Park, the northern half of Milton and Quincy and the southern half of West Roxbury and Dorchester. It is an area of great topographic as well as geologic complexity, and although, in general, low lying, includes, in Bellevue hill, the highest land within the Boston basin. The district here included in the Neponset valley is not now wholly drained by the Neponset river, this study naturally following geologic, more closely than topographic or hyprographic, boundaries.

The Lower Neponset valley is essentially an epitome of the entire basin, since it also consists of a central anticline of conglomerate bordered on either side by a well-defined slate syncline. The southern syncline, extending through Milton and Quincy, widens rapidly eastward, a somewhat open and composite trough, while the northern syncline, extending through West Roxbury and Dorchester, is a relatively deep and narrow isocline.

The immediate valley of the Neponset is developed in the complex and strongly denuded anticline which thus divides the more southerly of the two main troughs of the Boston basin, and which narrows eastward for the simple reason that the axis pitches or inclines in that direction. The prevailing sedimentary rock of this belt is conglomerate, and the attitude or structure of the conglomerate as a whole is anticlinal. It dips northward along the northern border, passing beneath the slate of the deep and nar-

row Dorchester-West Roxbury syncline; while along the southern border the dip is southerly and the conglomerate passes below the slate of the much broader and composite Quincy-Milton syncline. That the anticline itself is not a simple arch is plainly indicated by the narrow band of slate developed at intervals along the middle of the conglomerate belt and the existence of at least two anticlinal axes, pitching to the east and rising to the west, is further indicated by the fact that toward the west, where erosion has cut through the conglomerate and interbedded flows of basic lava we have exposed, not one, but two, ridges of the underlying crystalline rocks—granite and felsite—representing the floor upon which the conglomerate series was deposited. These two axes are, at most points, of unequal prominence; and in their denuded western extensions the northern axis largely predominates , forming the broad, irregular and broken ridge projecting into the Boston basin from the western highlands of Dedham and Needham and including the granite, quartz porphyry and felsite of the Bellevue Hill district and the Stony Brook reservation, the felsites of the northern part of Hyde Park and the felsites and more basic lavas of the Mattapan district of Dorchester. The minor southern axis is seen in the narrow band of felsite and basic lava, lying mainly south of the Neponset, between Readville and Milton Lower Mills.

Over a part of this area several flows of basic lava or andesite are interstratified with the conglomerate; and during the geological revolution or period of disturbance following the accumulation of these strata and the formerly overlying slate upon the old floor of felsite and granite, they were forced into a gigantic arch from one to nearly three miles broad. This great fold, however, partially broke down in the making, and its collapse was attended by the formation of the minor folds and numerous faults. Subsequent erosion has been so extensive as to remove the entire thickness of slate from the crest of the great anticline, except where it has been carried down most deeply by these minor folds and the faults, occurring now in narrow and discontinuous belts wedged in between the larger masses of conglomerate. The erosion has also been suffi-

cient to cut through the conglomerate series and the interbedded andesite, toward the western end of the arch, where they were most elevated, and thus expose the ancient foundation of felsite and granite.

Probably no phase of this study possesses a greater intrinsic interest than the comparison of the denuded major axis of the Neponset anticline with the Blue Hills complex, which is but the denuded axis of the great anticline separating the Boston and Norfolk basins; and aside from the disparity in area, it is surprising to find how marked is the similarity, except in minor details, and how few are the vital contrasts. In general terms, it may be stated that hardly anything is precisely similar in the two areas and nothing is radically different. In the smaller area as in the larger we have isolated masses of Cambrian strata involved in a complex of post-Cambrian granitic rocks, including the normal granite, the contact zone of fine granite and quartz porphyry, the effusive felsites and the intersecting dikes of diabase of several different systems. The chief contrast is found in the relatively greater abundance in the Neponset complex of the effusive felsites, their more varied character, the great profusion of dikes of felsite in the granites, the more positive identification of some of the principal vents or points of emission of these acid lavas, and the far more complete and clearer exhibition of their relations to the later basic lavas and the inclosing Carboniferous strata.

Among the problems of special interest presented by the Neponset anticline and, apparently, admitting of successful determination, may be mentioned: the detailed relations of the rocks of the basal complex; the mutual relations of the acid and basic lavas—rhyolite (felsite) and andesite; and the relations of both types of volcanics to the

THE BASAL COMPLEX.

The basal complex may best be defined as comprising all of the pre-Carboniferous terranes of this region, both sedimentary and eruptive; or more specifically, as consisting of the Cambrian strata and any other pre-Carboniferous and pregranitic sediments which future investigation may prove to exist here, together with the intersecting and associated igneous rocks of pre-Carboniferous age, includ-

ing the normal granite or main body of the batholite, and its contact zones of diorite, fine granite and quartz porphyry, and the dikes, necks and flows of acid lavas or felsites. As thus defined, the igneous part of the complex is clearly the product of the chemical and textural differentiation of a single great body of magma, embracing, besides the truly plutonic mass or batholite proper, developed, with its variable contact zone, under and in the Cambrian strata, the intrusive and effusive masses evolved, after extensive erosion of the Cambrian cover, from either still unsolidified or remelted deep-seated portions of the batholite.

That the batholite, with the complicating sedimentary and igneous phases, which gives it the character of a true and typical complex, is continuous under all the newer formations of the region and, in its successive phases, essentially contemporaneous throughout, is highly probable; and the variations observed from point to point must, therefore, be regarded either, as actual and due in part to differences in the original magma resulting from the fusion of the pre-Cambrian floor and in large part, also, to the varying thickness and composition of the original Cambrian cover, or as merely apparent and due to the varying depths of pre-Carboniferous and post-Carboniferous erosion, or again, as due to the localization of the intrusive and effusive phenomena which followed the formation of the batholite proper, adding greatly to its structural complexity.

If, with these ideas in mind, we compare more particularly than heretofore the portion of the basal complex rising westward from beneath the Carboniferous sediments of the Neponset valley with the portion exposed, as the result of still more extensive erosion, in the Blue Hills area, we find the more notable differences to be as follows: First, the normal granite of the Neponset valley is prevailingly coarser grained and the ferromagnesian constituent (chiefly hornblende) is more generally and extensively altered (chloritized). Second, the differentiation of the contact zone appears to have been almost wholly textural, and not, to any important extent, chemical, in the Neponset Valley district; and hence we find here only traces of diorite (which is also true of the Blue hills) and nothing closely

corresponding to the basic porphyry and the basic phase of the fine granite of the Blue Hills area. Third, the effusive acid lavas or felsites are, relatively, more abundant and far more varied in the Neponset valley than in the Blue hills. Fourth, the dikes of both acid and basic lavas so characteristic of the basal complex in the Neponset valley are practically or wholly wanting in the Blue hills. Fifth, the necks or actual vents of the effusive acid lavas are far more normally and typically developed in the Neponset valley than in the Blue hills, while the vents of the basic lavas are wholly wanting in the latter area. Sixth, the dikes of diabase, which are found in the eastern and northern parts, and are practically wanting in the main range of the Blue hills, are, in the Neponset valley, characteristic of all parts of the complex as well as of the overlying sediments, no considerable area being free from them. Seventh, erosion has left in the Neponset Valley section of the complex, so far as it is now exposed, only very scanty traces of the original Cambrian cover.

GENERAL HISTORY OF THE COMPLEX.

After what precedes a brief statement will suffice here, the main purpose being a more systematic outline, prefatory to the lithologic and structural details of the complex. As in the Blue Hills area, this area or part of the general batholite of eastern Massachusetts is believed to have been developed beneath a great thickness of Cambrian, and possibly of later, sediments, of which erosion has left only a few highly altered remnants. The thickness of the Cambrian cover was due primarily to extensive sedimentation and secondarily and chiefly to severe or isoclinal plication. The thickening of the super-crust thus determined was sufficient to induce a rise of the isogeotherms, an outflow of the subterranean heat, so marked as to involve softening and final fusion of the sub-crust or floor on which the Cambrian sediments were deposited, developing thus a great body of granitic magma, the corrosive action of which led to the absorption of considerable volumes of the sedimentary cover and gave rise, no doubt, to the normally highly irregular and unconformable contact.

This thickening of the super-crust and consequent great

heat invasion was, doubtless, accompanied by a strong elevation of the surface, permitting extensive erosion, which, in turn, favored the refrigeration of the batholite and the development from the originally homogeneous magma of a vast body of normal granite, with a contact zone consisting, normally, of an inner layer of fine granite and an outer layer of quartz porphyry, both phases of the contact zone being the products mainly of a textural rather than a chemical differentiation of the magma.

Long continued erosion, removing in large part the sedimentary cover of the batholite and probably cutting at some points through its contact zone into the normal granite, was followed by a period of volcanic activity, due possibly to cracking and hydration of the body of the batholite, during which, acid lava, chiefly rhyolite, now existing in a devitrified form as aporhyolite or felsite, was poured out over the eroded surface of the batholite. Several of the volcanic necks or vents of these effusive eruptions have been definitely located and their details of form and structure more or less fully worked out. From the vents or chimneys of these most ancient volcanoes of the Boston basin radial dikes of felsite extend outward into the granitic rocks. As a chronologically distinct record, the complex was now complete: but it was destined to be still further complicated; for these effusive acid eruptions appear to have marked the beginning of the progressive subsidence which inaugurated the deposition of the Carboniferous sediments, beginning with the great conglomerate series; and during the subsidence and clastic sedimentation the effusive eruptions continued, but became of more basic character—grading from rhyolite through trachyte to andesite, which in its present altered form as apoandesite or porphyrite has been heretofore classed as melaphyre, but is now known to be less basic than that type. The andesitic eruptions, from, presumably, greater depths than the source of the acid lavas, are marked by fissurelike necks, by numerous dikes cutting all the older rocks, and especially by successive massive flows or contemporaneous beds intercalated in the conglomerate series.

The volcanic activity finally ceased and continued sub-

sidence introduced the deep water conditions permitting the deposition of the slate series into which the conglomerate series gradually merges upward. The deposition of the slate series was closed, it is supposed, by the Appalachian revolution, during which the Carboniferous sediments were strongly folded and faulted and injected by still more basic magma from, possibly, still greater depths, forming the older or east-west series of diabase dikes, now largely chloritized or typical greenstone. Still later, and probably contemporaneously with the Triassic sedimentation and accompanying igneous activity in the Connecticut valley, were formed the diabase dikes of the newer or north-south series.

With this the rock formations of the Neponset valley were complete, and its later geological history is recorded only in the erosion accomplished during later Mesozoic and Tertiary ages and culminating in the great ice invasion of post-Tertiary or Pleistocene time.

THE CAMBRIAN STRATA.

The existing small remnants, the larger less than a thousand feet long, of the body of Cambrian strata which we suppose to have once formed a continuous cover over the batholite in the Neponset valley, as in other parts of the Boston basin, appear to be confined to the vicinity of the Boston and Hyde Park boundary, in the eastern part of the Stony Brook reservation and the immediately contiguous territory.

The sedimentary rock, of supposed Cambrian age, is all slate, of a uniformly massive, hard and distinctly metamorphic character. The prevailing color is dark gray; but it varies to lighter shades; and very generally the rock is perceptibly veined or clouded with the green of epidote, indicating that the slate was, originally, more or less calcareous, the lime having as an essential phase of the igneous matamorphism, combined with the alumina and silica of the slate to form epidote. This feature allies it with the Lower Cambrian slates of Weymouth, Quincy, Nahant, etc.; but in other respects it bears a striking resemblance to the massive, gray, non-calcareous Middle Cambrian slates, as these are developed on Hayward creek in Braintree and

along the north side of the Blue hills. It exhibits in a good degree the characters of a true hornstone; but it is nowhere of flinty hardness; and the fact that it is never visibly micaceous testifies to the essentially non-alkaline character of the sediment. As a rule, the stratification is hopelessly obscure; but at a few points, which are so distributed as to cover practically the entire group of ledges, it is fairly distinct and entirely unequivocal. The attitude of the bedding is, as usual in the Cambrian of the Boston basin, very constant, with east-west strike and vertical dip.

The essential relation of these sediments to the complex is clearly indicated, not alone by their metamorphic character, but also by typical igneous contacts with the fine granite and quartz porphyry of the contact zone, and irregular dikes or apophyses of the quartz porphyry and more regular dikes of normal felsite.

BODY OF THE BATHOLITE.

Normal Granite—This is a coarsely crystalline aggregate of feldspar and quartz, chiefly, with a small proportion of a dark constituent regarded by Dr. Bascom as chloritized amphibole. The feldspars, according to this authority, include orthoclase, commonly of a pinkish tint due to oxidation, and a lime-bearing albite in which the greenish tint due to epidotization is more or less marked. The analysis shows an acid rock, similar to the normal granite of the Blue hills, but rather more basic and richer in plagioclase, though poorer in the ferro-magnesian constituent.

The outcrops of normal granite are chiefly confined to two rather irregular areas; and the general relations of these to the complex is not central, as might seem most natural, but peripheral. They form, respectively, the northern and southwestern borders of the complex, and converge but, apparently, do not meet, to the northwestward, in the vicinity of Grove and Center streets. The dispositions of the normal granite is such as to suggest at once a general monoclinal or shallow synclinal structure for the complex,—the surface of the normal granite forming a trough the axis of which pitches to the southeast, thus allowing the normal granite to slope southward and northeatsward beneath the contact zone of fine granite and

quartz porphyry and a great thickness of volcanic and sedimentary formations. In the direction of its disappearance the normal granite does not reappear north of the Blue hills; and undoubtedly its disposition, especially in relation to the unaltered sedimentary formations which meet it abruptly on the north, in the West Roxbury district, finds its readiest explanation in a profound displacement along the northern border of the complex, with the downthrow, of course, to the north.

The normal granite is observed at many points to grade upward into the fine granite by which it is bordered; and its surface continuity is frequently interrupted by island-like outliers of the fine granite. These relations are particularly well-exhibited in the broad and massive ledges in the area bounded by Washington, Grove and Center streets and Cottage avenue; and nowhere more favorably than in the vicinity of the large quarry on Cottage avenue, northwest of Washington street.

CONTACT ZONE OF THE BATHOLITE.

Fine Granite—The chief difference between this type and the normal granite is textural. The essential minerals, according to Dr. Bascom, are the same, with the addition of a little microcline and oligoclase to the feldspars. Quartz is reported as more abundant, and the chloritized ferromagnesian constituent as less so, and these distinctions are confirmed by the analysis, which shows higher silica and lower lime, magnesia and iron.

The fine granite belongs to the contact zone and hence overlies the normal granite. It might, therefore, where not removed by erosion, be expected to exhibit a broad areal development, but for the fact that it is, in turn, covered by the quartz porphyry phase of the contact zone. In harmony with this general relation and the shallow synclinal structure of this part of the batholite, the principal area of the fine granite takes the form of an irregular V-shaped belt, 1000 to 3000 feet wide, separating the normal granite on the north and southwest, from the quartz porphyry on the south and northeast, respectively.

As to the thickness of the fine granite, we have no very definite clue. No approximately vertical or continuous

section shows both the normal granite below the fine granite and the quartz porphyry above it. In other words, we have no data for a direct determination of the thickness, save that it must exceed the hight of the highest hill composed wholly of the fine granite, or say 75 feet. It would be readily deducible from the surface breadth if the dip were known. Assuming the dip to be low and inversely proportional to the surface breadth, gives a maximum thickness of a few hundred feet at the most; and 100 to 200 feet may, perhaps, be accepted as a conservative estimate, confirming the conclusions reached in the study of the Blue Hills complex.

The finer granite of the contact zone is, in a fair sense, a bed of passage, since it grades downward into the normal granite and upward into the quartz porphyry; and, normally, its original contacts are nowhere sharply defined, but distinctly blending. It may be noted, however, that, as in the Blue Hills complex, the contact with the normal granite, though blending, is rather abrupt, the complete transition from the one rock to the other being ac-
passage upward into the quartz porphyry is usually more
or, possibly, in extreme cases, a single foot. Although the
complished in some exposures in the breadth of a few feet
sedimentary rocks.
gradual, all observers must recognize that the fine granite, so far from being all gradation, is chiefly remarkable for the uniformity of texture throughout almost its entire thickness. In fact, it rivals the normal granite in this respect. Locally, and especially near the quartz porphyry, it may pass into a true microgranite; but it is in general a macrogranite of very homogeneous aspect.* That the fine granite is older than the normal granite and younger than the quartz porphyry, and that these three distinct but blending sedentary zones of the batholite exhibit the structural relations which this sequence requires, will probably not be questioned by those familiar with the field evidence.

* The explanations of the homogeneity of the fine granite and its abrupt yet blending passage into the normal granite suggested in Part III. of the Boston Basin Geology (Occas. Papers, Boston Soc. Nat. History, iv, 354 et seq.) are still regarded as valid, and as applicable in this new field.

Quartz Porphyry—This upper or peripheral member of the contact zone has been designated by Dr. Bascom the rhyolitic facies of the granite or more succinctly rhyolite, and more explicitly porphyritic aporhyolite; and for this usage the petrographic characters undoubtedly afford ample warrant. But in order the more sharply to distinguish this essentially plutonic type from the much younger and very dissimilar intrusive and effusive rhyolites, it is proposed to employ here the good descriptive term quartz porphyry. The rock in question is in every instance a true quartz porphyry, with conspicuous phenocrysts of both quartz and feldspar; and, as befits its plutonic origin, it is of remarkably uniform character, matching the granites in this respect; while the clastic, fluidal and spherulitic structures so characteristic of the newer rhyolites are conspicuous by their absence. Such variation as the quartz porphyry shows is due chiefly to its gradation downward into the fine granite; and, as Dr. Bascom has noted, its texture, though aphanitic, allies it with the micrographitic phase of the fine granite, and unlike the younger rhyolites it is rarely truly cryptocrystalline.

In its distribution the quartz porphyry tends to form a V-shaped zone concentric with the fine granite, and separating the underlying fine granite from the overlying effusive rhyolite or felsite. The lower border of the quartz porphyry is rendered rather vague and indefinite at most points by its blending contact with the fine granite. The upper border, on the other hand, where the quartz porphyry meets the effusive rhyolites or felsites is, in the nature of the case, sufficiently definite but highly irregular, since we have here a true erosion unconformity, and two formations, although of closely similar composition and probably derived from the same original magma, are strongly contrasted in structure and widely separated in geological time.

Summary and Comparison—Neglecting unimportant occurrences of diorite and aplite, which may be described, respectively, as relatively basic and relatively acid phases or segregations of the normal granite, and hence as products of a chemical differentiation of the main body or

primal magma of the batholite, we have now considered all of the sedentary or truly plutonic rocks of the batholite. These have been described in the order of superposition, which is, of course, the inverse order of age, since the refrigeration of the batholite must have progressed from the periphery downward or centripetally. That the differentiation of the normal granite and the contact zone, and the further differentiation of the fine granite and quartz porphyry of the contact zone, are not wholly textural is, as noted by Dr. Bascom, clearly shown by analyses, according to which the normal granite is the most basic and the fine granite the most acid, while the quartz porphyry is intermediate in composition, although not so in position. By way of explanation of this chemical relation, Dr. Bascom has suggested that specific gravity and convective currents may have been factors in producing a somewhat more acid peripheral zone to the batholite, while the outer or quartz porphyry border to this zone, following the general law of the order of crystallization (virtually fractional crystallization), by its earlier crystallization left the inner portion of the zone or fine granite more acid than either the quartz porphyry or normal granite. To this explanation may, perhaps, be added the influence of hydration. It appears reasonable to suppose that the primal magma of the batholite, formed under a thick and, necessarily, a hydrated sedimentary cover, and due in part to the absorption of large volumes of this cover, would naturally be more highly hydrated in its superficial than in its deep-seated portions; and since the characteristic elements of an acid magma, including silica and the alkalies, have a stronger affinity for water than have the lime, magnesia and iron oxide characteristic of basic magmas, we have here a cause tending to keep, if not to make, the batholite superficially acid.

That, in comparison with the granitic rocks of other districts, this part of the batholite was formed under a moderate depth of cover, is believed to be indicated by the relatively slight amount of chemical differentiation, by the absence of an original micaceous constituent, and especially by the almost entire absence of a pegmatitic phase in the normal granite. The absence of marked differentiation ex-

tends, in the main, to the earlier intrusions in the batholite, since, with one exception, these are relatively acid, and differ but little in composition from the sedentary members of the batholite.

(Continued in August Number.)

EDITORIAL COMMENT.

ANOTHER METEORITE IN THE SUPREME COURT.

It was decided by the Iowa supreme court, in the case of the Winnebago meteorite, that the meteorite belongs to the owner of the land on which it falls. The tenant found the stone and sold it. The owner brought suit to regain it, and after some years of litigation and delay the court assigned the meteorite to the owner of the land.

The Oregon meteorite case is somewhat different. A metallic mass is admitted by both parties to be of meteoric nature and origin, and as such, according to the Iowa decision, it belongs to the owner of the land on which it fell. The date of its fall however is unknown, and there is evidence tending to show that it was a piece of personal property, separate from the land on which it was found, for many years prior to the date of discovery. The issue and the attendant conditions have been stated as follows by the *Oregon Journal:*

The Oregon City meteorite case was argued before the supreme court yesterday. This is an action brought by the Oregon Iron & Steel company to obtain possession of the metallic meteorite found by Ellis Hughes in November, 1902, on the land of the Oregon Iron & Steel company, about two and a half miles west of Oregon City. The interesting subject of this controversy was found standing upright on a slight knoll. It is of metallic composition, with a dull, rusty surface, its top or flat surface being gouged out into huge potholes or washbowls. As it stood it resembled very much in appearance a mammoth mushroom or inverted bell, in size seven by ten feet across at the top, and four and a half feet thick, its weight being estimated at from three to four tons. It has the specific gravity of soft iron, and in composition is 90 per cent soft iron, 10 per cent nickel, with a trace of cobalt.

Hughes alleged that this was an abandoned Indian relic and

that he was the first white discoverer of it and, believing he had a right to it, he constructed a rude wagon and hauled it to his own home, about three-quarters of a mile distant. He alleged that this meteorite was the property of the Clackamas tribe of Indians (now disbanded and nearly all dead), and that they had a tradition that this magic rock, called by them "Tomanowos," came from the moon, and possessed supernatural influence. He claimed that it was fashioned, erected, maintained and used by them to hold the fluid in which they were wont to dip their arrows before engaging in battle with their Indian foes, and that their young warriors were compelled to journey over there and visit this spirit being on the darkest nights. To substantiate these claims two Indian witnesses were produced, who testified that the above facts were true, according to the legends of their tribes. One of them was a member of the Klickitat tribe of Indians and the other was a Wasco Indian.

Both parties to this case agree that the object is a meteorite, but no proof has been offered by either to show when it arrived on earth. The Oregon Iron & Steel company denies that it is an Indian relic, and claims title to it by virtue of ownership of the land upon which it was found.

It may safely be assumed, probably, that this iron fell on the land where it was found, although there is no proof of it. The Indians who previously visited and worshipped it could not have transported it. If they had ownership of the land they owned the specimen. As they did not remove it, when the land passed from them it would seem that the meteorite went with the land. But the consideration that they had used it as a special object, for a special purpose, foreign to the uses to which land as such is devoted seems to make it an object of personal property. They may have erected it in the position in which it stood, and may have deepened the "potholes" on its upper surface. If a man sculptures a statue from some rock on his land, when he sells the land the statue does not go with the land. If the Clackamas Indians did not own the land, and yet visited and controlled the specimen for a specific use without objection from others, it seems reasonable to assume that the specimen was not an appurtenance of the land and that they had the right to remove it. If they abandoned it, without removal, it seems to belong to that class of Indian relics of which many examples are known and which the finder, rightly or wrongly, becomes the owner.

If the specimen is an Indian relic the ownership thereof

may still be in the owner of the land. He is a trespasser who wilfully passes on to his neighbor's domain; and he is still more a trespasser if he removes, against the owner's protest, any of the property of his neighbor. N. H. W.

Note.—Since the foregoing was written the Oregon supreme court has decided this case, as follows, as published in the Portland Oregonian:

Oregon Iron and Steel Company, respondent, vs. Ellis Hughes, appellant, from Clackamas county, T. A. McBride, judge; affirmed; opinion by Chief Justice Wolverton.

Held, that a meteoric rock is a part of the real property upon which it falls, and evidence that Indians worshipped the rock and dipped their arrows in the water held in its cavities is not sufficient to show that the Indians had dug the rock from the ground and acquired title to it as personal property. The question whether Indian ownership and abandonment is sufficient ground upon which to predicate title in the finder is not decided.

The court did not consider the evidence as to the ownership of the specimen as personal property by the Indians of sufficient force to warrant the reference of the case to a jury for determination. That evidence failing, there was left the bare question as to whether the meteorite belonged to the real estate or to the finder. In that the Oregon court coincided with the Iowa court *in re* Winnebago meteorite. N. H. W.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Contributions to Devonian Paleontology, 1903. Henry Shaler Williams and Edward M. Kindle. Bull. U. S. Geol. Surv., No. 244, 1905, pp. 1-144.

Bearing of Some New Paleontologic Facts on Nomenclature and Classification of Sedimentary Formations. Henry Shaler Williams, Bull. Geol. Soc. Amer., Vol. 16, March, 1905, pp. 137-150.

Bulletin No. 244 consists of two parts, No. I. listing and discussing "Fossil faunas of the Devonian and Mississippian (Lower Carboniferous) of Virginia, West Virginia and Kentucky," while part II. considers in a similar manner the "Fossil faunas of Devonian sections in central and northern Pennsylvania." A large number of sections in Kentucky, Virginia and West Virginia are

described by Dr. Kindle and accompanied by lists of fossils of the various faunules. The above is followed by a series of short articles, among which may be mentioned "Correlations," "The *Rensselaeria* fauna," "The black shale and its fauna," "The upper Devonian faunas of the middle Appalachians" and a "List of diagnostic Chemung species" by professor Williams. In part II. the descriptions of the sections in central and northern Pennsylvania are mainly by Dr. Kindle; but the formational and faunal correlation is considered much more fully than in the preceding part by both Kindle and Williams.

These two papers have recently been reviewed by professor Schuchert* who considered critically the lower Devonian, or the Helderbergian and Oriskanian series. It appears that similar notes concerning the middle and upper Devonian, to which this review will be largely restricted, might be of value.

Professor Schuchert seems inclined to question the identification of *Anoplotheca acutiplicata* from the black shale near Covington and Hot Springs, Virginia. The writer considers that the identification is probably correct, for the same species occurs near the base of the black shale or Marcellus member of the Romney formation in western Maryland. The Maryland specimens were examined by Dr. John M. Clarke so that no question can be raised regarding their specific identity. From the occurrence of the above species and *Anoplia* associated with others which are "regarded as confined to the Marcellus shale of New York" professor Williams concludes "that the black shale was deposited in a thick mass in the Appalachian trough before the fauna of the Onondaga (Corniferous) formation was extinct." In connection with the above it is well to remember that the Onondaga fauna entered New York from the west and, generally, is supposed to have reached no farther south than northeastern Pennsylvania. Dr. Clarke has shown that "early Marcellus deposits in eastern New York were * * * contemporaneous with late Onondaga deposits in western New York."†

On page 45 of the Bulletin professor Williams speaks of the Romney formation as though it were composed entirely of black shale and this idea is expressed by him more distinctly in the second paper under consideration. The term Romney formation was first published by Mr. Darton in 1892 in this journal and was applied to the rocks in the vicinity of Romney, a town scarcely 15 miles south of the Potomac river in Hampshire county in the northern part of West Virginia. It is located within the Potomac basin and there is very slight change in the lithology or fauna of the deposits in western Maryland to which this name has subsequently been applied. The writer has shown that both on lithological and faunal grounds the Romney formation of northern West Virginia and western Maryland may be divided into two members. The lower one is composed principally of fissile black shale, weathering

* Am. Jour. Sci., 4th Ser., Vol xix, June, 1905, pp. 460-463.
† N. Y. State Museum, Bull. 25, 1905, p. 668.

to a brownish or buff color, together with some bands of dark-colored thin limestone, with a total thickness of about 500 feet. The limestones contain *Agoniatites expansus* (Vanuxem) which is so characteristic of a thin limestone in the lower part of the Marcellus shale in New York that its generic name has been given to it, while the black shales contain numerous specimens of *Liorhynchus limitare* (Vanuxem) and some other species which are regarded as characteristic of the New York Marcellus shale. In a general way this member corresponds with the Marcellus shale of New York with which it has been correlated. The upper member is composed of bluish or bluish-gray shales and sandstones with an approximate thickness of 1,100 feet. This member contains numerous specimens of characteristic Hamilton species of New York and frequently the entirė 16 species which professor Williams has previously listed as the "dominant species of the Hamilton formation of eastern New York and Pennsylvania." Evidence indicates that the deposits of the Romney formation in Maryland apparently closed at about the same geological time as the Hamilton beds of New York, and in a general way this member has been correlated with the Hamilton beds of New York. It is not intended to state that the limits of the Romney formation in northern West Virginia and Maryland are *exactly* contemporaneous with the limits of the Erian series of New York; but there is a striking similarity in most details and it is believed that there is no serious error in this general correlation.

The deposits, called Romney shale, which professor Williams has studied in the field, their fossils in the laboratory, and discussed in Bulletin No. 244 are located in southern Virginia and eastern Kentucky. These collections later were supplemented by others made by Dr. Kindle in Kentucky, Virginia and southern West Virginia. It appears, however, that the locality farthest north from which collections were made is 110 miles or more to the southwest of Romney and, apparently, the nearest outcrops of the so-called Romney shale which professor Williams studied in the field are 220 miles or farther to the southwest of that town. It is well known that there is a rapid thinning and marked lithologic change in the Devonian deposits as they are followed from the Potomac basin to the southwest. Professor Williams' own statement "that in the correlation of local formations the same species of fossils alone (when so much as 50 miles of distance separates their stations) can not be relied on for establishing more than a general homotaxial relation of the formations compared"* would suggest caution in correlating with the Romney formation the deposits of Bland county in southwestern Virginia, 220 miles to the southwest. The statement of professor Williams that "the rocks belonging to the part of the column called Romney, in central and southern Virginia, contain chiefly the faunas found in New York in the Marcellus, Genesee, and Nunda ('Portage') with only traces of the Ham-

* Bul. Geol. Soc. Amer., vol. 16, p. 147.

ilton fauna near their base"† is probably true for the region which he studied but is incorrect for the Potomac basin in which the typical outcrops of the Romney formation occur. As we have shown above, the Romney formation in its standard region contains in its lower member essentially the fauna of the Marcellus shale and in its upper member that of the Hamilton beds of New York. It is not until in the succeeding or Jennings formation that the Genesee, Naples or Portage, Ithaca and Chemung faunas are found.

Probably that portion of part II. of most general interest is the discussion and correlation of sections in Northumberland and Columbia counties of central Pennsylvania which had been adopted as standard ones by the state survey in the interpretation of the geology of that part of the state. Perhaps the most important one is the Catawissa section on the Susquehanna river which was very carefully studied by Dr. Kindle in the field and the correlation reviewed by professor Williams. Dr. Kindle shows that the calcareous shales in this section which were correlated with the Tully limestone by the Pennsylvania survey contain a Hamilton fauna, "not one of the characteristic Tully forms appearing." Dr. Kindle, however, considered that the zone "occupies the stratigraphical position of the Tully limestone of New York" while professor Williams stated that it and the two subjacent zones contain "the normal fauna of the Hamilton formation." The writer showed in 1894 that the calcareous shale in Pike and Monroe counties in northeastern Pennsylvania, which the state survey correlated with the Tully limestone of New York is succeeded by some 200 feet of very fossiliferous shales containing a characteristic Hamilton fauna which he referred to the Hamilton formation.* The investigations of Dr. Kindle clearly show, however, that the calcareous shales of central Pennsylvania correlated with the Tully limestone of New York by the Pennsylvania Survey occur at a higher stratigraphic horizon than those of northeastern Pennsylvania as was inferred and published by the writer in 1894.‡ The succeeding 225 feet of bluish-black shales are correlated, on account of lithological similarity, with the Genesee shale and rather more than 25 feet above their top appears the first faunule of the Nunda (Portage) formation. Professor Williams states that the name Nunda formation has been adopted to designate what has heretofore been called the Portage or Nunda group. Two hundred feet above the top of the Genesee shale is a faunule containing *Spirifer pennatus var posterus* which is considered as the first appearance of the Ithaca fauna that then continues through about 1,400 feet of deposits to almost the base of the lowest red shales. Dr. Kindle states that no characteristic Chemung forms appear in these deposits and professor Williams concludes that "Faunally the evidence of the Chemung formation

†Ibid, p. 143.
*Bul. U. S. Geol. Surv., No. 120, pp., 71-73.
‡ Ibid., p. 73.

must be looked for in the still higher strata." The last deposits considered were correlated with the Chemung formation by the Pennsylvania survey in the upper portion of which they reported the characteristic Chemung species *Spirifer disjunctus*. From the lowest reported horizon of this species Dr. Kindle carefully searched every remaining foot of the so-called Chemung deposits without finding a single specimen of *Spirifer disjunctus*. This is in perfect harmony with the writer's experience in northeastern Pennsylvania where he failed to find this species which was reported in rocks of so-called Chemung age.* This detailed work of Kindle and Williams confirms the writer's correlation in 1894 of the so-called Chemung of northeastern Pennsylvania with the *Paracyclas lirata* fauna of the Portage of eastern New York† which later he demonstrated belonged in the Ithaca formation.‡ It is interesting, however, to remember that farther to the southwest in western Maryland the higher Devonian faunas contain numerous specimens of *Spirifer disjunctus* associated with some of the other species which professor Williams lists as diagnostic of the Chemung. C. S. P.

MONTHLY AUTHOR'S CATALOGUE

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† Ibid., pp. 11, 76, 78.

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The Mesabi Iron Ore Range, xi. (Eng. Min. Jour., vol. 79, p. 892, May 11, 1905.)

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WRIGHT F. E. (and C. W. WRIGHT).

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CORRESPONDENCE.

Estimation of the Silica in the Bedford Limestone—The specimen used in this work was obtained from a quarry near Bedford, Indiana, and it is known locally as the Bedford limestone. It is a light-colored rock, fine grained in texture, and is widely used and favorably regarded as a building material.

The amount of residue insoluble in hydrochloric acid which proved to be mainly silica was determined by three different methods as follows:

Method 1.

A grain of the fine powder was placed in a small beaker covered with a watch glass. Dilute hydrochloric acid was added and the contents of the beaker gently heated to boiling. After standing a short time, the undissolved portion was filtered off and the weight determined.

Method 2.

A grain of the powder was placed in a porcelain evaporaing

dish, and while covered with a watch glass, dilute hydrochloric acid was added. It was left on the water bath until effervescence ceased, the accumulations on the watch glass were rinsed off, and the evaporation continued until crystals began to appear. Then as the evaporation went forward, the substance was stirred with a glass rod until a fine dry powder resulted. This was moistened with concentrated hydrochloric acid and left on the water bath for a few moments. Dilute hydrochloric acid and water were added and after sanding a short time, the insoluble residue was filtered off, dried in the air bath, and its weight determined. The insoluble residue was obtained three different times by each of the two methods, varying the weight of the original amount taken. The results were as follows:

Method 1.

(a)	With one gram substance	0.54 per cent.
(b)	" three grams "	0.56 " "
(c)	" ten " "	0.55 " "

Method 2.

(a)	With one gram substance	0.65 per cent.
(b)	" three grams "	0.55 " "
(c)	" ten " "	0.55 " "

To determine further the nature of the residue, whether it was all silica, or wholly or partly a silicate, it was treated in the platinum crucible with a few drops dilute sulphuric acid, and the crucible was nearly filled with a dilute solution of hydrofluoric acid. It was evaporated on the water bath and the excess of sulphuric acid removed with the free flame.

Residue in Crucible obtained by method 1:

(a)	One gram substance	0.13 per cent.
(b)	Three " "	0.12 " "
(c)	Ten " "	0.14 " "

Residue in Crucible obtained by method 2:

(a)	One gram substance	0.13 per cent.
(b)	Three " "	0.12 " "
(c)	Ten " "	0.11 " "

A blank test was made using sulphuric and hydrofluoric acid in the crucible and evaporating to dryness. No residue was obtained.

The residue in the crucible was determined and found to be

Aluminum and iron sulphate	0.08 %
Calcium sulphate	0.058 %
Magnesium sulphate	0.00
	0.138%

Method 3. To compare the insoluble residue obtained by fusion with alkaline carbonate with the amount obtained by the foregoing methods.

A gram of the fine rock powder was thoroughly mixed in the

platinum crucible with seven grams of anhydrous sodium carbonate. The sodium carbonate used was a good quality of Merck's manufacture. It was further purified by dissolving a quantity in water and filtering. This after fractional crystallization seemed to be entirely free from silica. The covered crucible was heated for fifteen minutes with a Bunsen flame, then with a blast lamp to complete fusion. The cooled mass was transferred to a porcelain evaporating dish and dissolved in dilute hydrochloric acid. Evaporation was continued on the water bath until crystals began to appear. It was then stirred with a glass rod until a fine dry powder was obtained. It was treated with hydrochloric acid as in method 2 before described. The insoluble residue obtained by this method amounted to 0.53%. This treated with sulphuric and hydrofluoric acids left a residue of 0.16%. The results are fairly concordant with those obtained by methods 1 and 2, but on account of the difficulty of getting pure sodium carbonate, and the length of time and the labor necessary to obtain the result, this process is not to be commended with rocks of this character. Indeed method 1 is greatly to be preferred, whenever circumstances permit, on account of its simplicity, and the shortness of time required.

During the course of this work our attention was called to the estimation of silica as outlined by Treadwell* in his excellent treatise on quantitative analysis. After removing the insoluble residue according to method 2, it is stated that "as much as 5 per cent of the total amount (of silica) may remain in the filtrate. In order to remove this the filtrate from the first precipitate is once more evaporated to dryness on the water bath and kept on the hot water bath for one or two hours or more." It is then filtered after treatment with hydrochloric acid and water in the usual manner.

Several determinations were made in which the suggestions of Treadwell were strictly carried out. One gram, five grams and ten grams of substance were used. In no case was even a trace of residue obtained by the second treatment. The experiment was varied by using a specimen of argillaceous limestone that contained 18 per cent of silica. A second portion of residue could not be obtained from this specimen.

A complete analysis of the Bedford limestone resulted as follows:

$Ca\ Co^3$	93.55%
$Mg\ Co^3$	5.42%
$Si\ O^2$	0.55%
$Fe^2\ O^3$ and $Al^2\ O^3$	0.50%
	100.02%

The condition of the iron was tested by placing three grams of the powdered rock in a flask of 12 c c capacity, fitted with a bulb

* Treadwell-Hall's Quantitative analysis, page 384.

tube and Bunsen valve. The material was dissolved in a small quantity of dilute hydrochloric acid. A few drops of the solution quickly withdrawn and placed on a porcelain tile in contact with a solution of potassium ferricyanide showed a slight tinge of blue. A few drops of a solution of potassium sulpho cyanate were then quickly introduced into the flask when a red color was produced. The portion of the iron soluble in hydrochloric acid is therefore of both the ferrous and ferric forms. No attempt was made to determine each quantitatively on account of the small amount.

The writer acknowledges his indebtedness to Alys Boies Carson for making the experiments of this investigation.

NICHOLAS KNIGHT.

Chemical Laboratory, Cornell College,
July 4, 1905.

PERSONAL AND SCIENTIFIC NEWS.

PROF. W. W. MILLS has been appointed state geologist of Michigan to succeed Prof. A. C. Lane.

DR. O. C. FARRINGTON has recently returned, from a long trip, to the Field Columbian Museum.

MR. W H. HARVEY of Eveleth, Minnesota has been appointed inspector of mines, with headquarters at Eveleth.

DR JOHN M. CLARKE. Director of Science and State Geologist of New York, as well as one of the editors of this journal, has been seriously ill with appendicitis.

MR. GEORGE F. LAMB, a graduate of Ohio university and later a graduate student in geology at Ohio State university, has been elected professor of Biology and Geology in Mount Union college at Alliance, Ohio.

THE "MINING WORLD" of Chicago has recently been purchased by a new stock company. The editorial staff has been strengthened and enlarged, under the direction of Mr. D. T. Day.

PROF. J. VOLNEY LEWIS of Rutger's college will devote the summer to a special investigation of the petrography of the Newark (Triassic) traps of New Jersey and their associated copper ores for the state geological survey.

DR. M W. TWITCHELL, a graduate of Columbian university, Washington, D. C., and of Johns Hopkins university, Baltimore, Md., has been elected to fill the chair of geology in South Carolina college at Columbia, S. C.

MR. ERNEST C. BROWN, publisher of "Progressive Age," is preparing to publish a complete list of the engineers of

America. He has listed already over two thousand and desires information concerning five or six thousand others.

WARREN UPHAM contributes a paper of eighteen pages, entitled "Geological History of the Great Lakes and Niagara Falls," to the July number of The International Quarterly.

DAVID T. DAY of the U. S. Geological Survey has recently made a visit to the Yellowstone Park. He is now in charge of the concentration of black sands carried on by the survey at the Portland exposition, where he also holds the position of honorary chief of the mines department.

MR G. K GILBERT has given to the Department of Geology of Denison university upwards of 1,000 volumes of literature, consisting of U. S. G. S. reports, state reports, reprints, proceedings, and other valuable books. This gift is especially appreciated after having lost their library in the burning of their Science Hall.

THE POSITION OF THE LATE ALBERT A. WRIGHT of Oberlin college has been filled by the election of Maynard M. Metcalf, professor of Biology in the Woman's college of Baltimore, as professor of Zoölogy and Mr. E. B. Branson of Kansas university as instructor in Geology. Dr. Metcalf was granted a two years' leave of absence and the work for the ensuing year will be conducted by Dr. Lynds Jones, associate professor of Zoölogy and Mr. Branson.

THE SET OF CHARTS illustrating the origin of certain metallic ores, prepared by C. R. Van Hise, C. K. Leith and W. N. Smith and exhibited at the St. Louis Exposition, has been reproduced in Vandyke prints for limited distribution, in response to requests for copies. The prints are four in number, iron, copper, gold and silver, and lead and zinc, each about 24 by 50 inches. A charge of 75c each is made to cover cost. Orders may be sent to C. K. Leith, Madison, Wis.

PROF C. H. HITCHCOCK, of Dartmouth college, will spend the months of July and August in the Hawaiian Islands, to visit again their principal volcanoes, all of which he has ascended during his numerous former explorations of these islands. His observations this summer are for revision and completion of a treatise on volcanoes, and especially on their very exceptional characters in the Hawaiian group.

DR. GEORGE D. HUBBARD, instructor in geology and physical geography in Cornell university has been elected assistant professor of Geology in Ohio State university. The other members of the Geological department are Charles S. Prosser, professor of Geology and John A. Bownocker, professor of Inorganic Geology. In recent years

the department has grown very rapidly and during the last four years the number of students has nearly trebled. During the present summer session the instruction in geology is given by Dr. Aug. F. Foerste of Dayton.

"IT WAS STATED IN THE ISSUE OF SCIENCE for April 21, that the New Mexico legislature had appropriated $6,000 for a state geological survey, to be spent under the direction of the New Mexico school of mines at Socorro. We are informed that the only reference to such a survey occurs in the general appropriation bill and is as follows: 'For publication U. S. Geological Survey reports, to be expended under the direction of the Socorro School of Mines, or so much thereof as may be necessary, $2,500.'"—*Science.*

A similar misstatement was published in the GEOLOGIST for April (p. 262).

THE DELAYED ANNUAL REPORT of the Geological Survey of Michigan for 1903 is out. It consists of 342 pages and contains report of the state geologist and included papers. Among the noteworthy articles are those on the soils and vegetation of Roscommon and Crawford counties by B. E. Livingston, and notes on the waters both of the Upper and Lower Peninsulas. There are articles on the theory of copper deposition and the Keewenawan lodes. The report is sent gratis on payment of forwarding charges (13 cents) to teachers for professional use, editors for review and to libraries according to the rules of the Board whose office is at Lansing, Michigan.

THE LATE LEGISLATURE OF ILLINOIS established a state geological survey, putting it under the immediate direction of the trustees of the state university, located at Champaign, but with an advisory board consisting of the governor, the president of the university and one other to be appointed by the governor. The annual appropriation is twenty-five thousand dollars.

In addition to the above the university is to have a school of ceramics, supported by an appropriation of five thousand dollars per year. This, however, will have no connection with the survey except such as common interest dictates.—*Rolfe.*

CONGRESS OF APPLIED GEOLOGY. An international congress of applied geology was called to meet at Liege from 25 June to 1 July, 1905. It took place in connection with the Universal Exposition of Liege, and of the International Congress of mines, metallurgy, mechanics and applied geology, of the last of which it seems to be an offspring. The president and the secretary of the Committee of organization are respectively Max Lohest and René D' Andrimont, both of Liege. Amongst the organizing members

are named the following: Ch. Barrois, P. F. Chalon, De Launay, H. Domage, E. Dubois, J. Gosselet, H. Höfer, K. Keilhack, F. Laur, H. Louis, M. Lugeon, H. Potonié, Schulz-Briesen, F. Villain and numerous Belgian geologists.

THE SCIENTIFIC WORLD will be specially interested to learn that Dr. G. F. Wright, is about to make an expedition to southern Russia and the north end of the Red sea, to complete the investigations begun by him in 1900 and 1901, the object of which was to determine the physiographic changes which have taken place in comparatively recent times in the regions earliest occupied by man, and to ascertain the influence these have had upon the history of the human race.

This expedition is made possible by a special fund presented him as president of the Records of the Past Exploration Society for this particular work. Full reports of his investigations will appear in Records of the Past during the autumn and winter.

During his trip he will receive mail, in care of the American Consulate, at the following points:—Aug. 12, York, England; Aug. 25, Copenhagen, Denmark; Sept. 8, Moscow, Russia; Sept. 15, Vladikavkaz, Russia; Sept. 25, Sevastopol, Russia; Oct. 5, Constantinople, Turkey in Europe; Oct. 15, Beirut, Syria; Oct. 25, Jerusalem, Palestine; Nov. 5, Cairo, Egypt; Nov. 13, Athens, Greece; Nov. 20, Naples, Italy; Dec. 1, Rome, Italy; Dec. 20, Paris, France; Jan. 1, London, England.

BULLETIN NO. 60, OF THE BUREAU OF FORESTRY being a "Report on an Examination of a Forest Tract in Western North Carolina," by Franklin W. Reed, will soon be ready for distribution.

This report contains a comprehensive and detailed description of the forest on about 16,000 acres in the mountains of western North Carolina, which is to be lumbered so that its value as a summer resort shall not be impaired. This tract is typical of many others in the southern mountains, where undeveloped resources afford an opportunity for the practice of forestry or conservative lumbering. The conditions described in this bulletin furnish a concrete example of what such land will yield when placed in the care of a forester, who will look after its landscape features while cutting the merchantable timber. Tables of growth and yield are provided, logging and pleasure roads located, and a system of fire protection outlined.

The bulletin is illustrated with a topographic map and six plates. Application for this bulletin should be made to The Forester, U. S. Department of Agriculture, Washington, D. C.

THE TECHNOLEXICON OF THE SOCIETY OF GE GINEERS (short report on the state of work June, the compilation of this universal technical dict translation purposes (in the languages English and French), that was commenced in 1901, about and individual collaborators at home and abroad ing at present.

Up to now 2,700,000 word-cards have been To these will be added the hundred thousands of will result from the working-out of the origina tions not yet taken in hand. The contributions called in since Easter, 1904, and most of them ha come in (up to June, 1905: 1480).

The editor-in-chief will be pleased to give a information wanted. Address: Technolexicon, I Jansen, Berlin (NW. 7), Dorotheenstrasse 49.

A SPECIAL SUMMER MEETING OF THE AMERICA POLOGICAL ASSOCIATION will be held in San Fran fornia, on August 29, 30 and 31. After the me will be an excursion to Portland, Oregon, to visit & Clark Exposition. Here an informal meetin held at which addresses will be made.

The meeting in San Francisco will be held auspices of a local committee. This committee w for excursions and entertainments. The head the Association will be the Department of An of the university of California at the Affiliated Co Francisco.

Since special rates are being given by the nental railroads to Portland via San Francisco, i ceptional opportunity for ethnologists and archæ visit the Pacific coast.

Members intending to be present will please secretary of the local committee, Dr. A. L. Kro ated Colleges, San Francisco. Dr. Kroeber will hotel accommodation and will furnish informati to the meeting.

The amendments to the constitution propo Philadelphia meeting (see Amer. Anthropologis 176) and at the council meeting of April 15, 19 been approved by the council, will be presented at cisco for adoption.

Mr. George Grant MacCurdy, 237 Church s Haven, Conn., secretary of the Association, will mation as to special railroad rates. Titles of pa be sent to him at an early date.

Albert A Wright.

THE

AMERICAN GEOLOGIST.

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ALBERT ALLEN WRIGHT.

By PROF. G. F. WRIGHT, Oberlin, Ohio.

PORTRAIT—PLATE III.

On the afternoon of Saturday, April 1, 1905, professor Albert Allen Wright was about his usual duties, but upon going to his study upon his wheel was suddenly seized with spasms of pain which, after continuing for twenty-four hours, ended in his death, upon Sunday afternoon. For some years professor Wright had suffered more or less from ill health, for which physicians found it difficult to account. A year of rest upon the Pacific coast in 1900 failed to bring the expected relief, but partial relief was found in a severe course of dieting. The mystery, however, was solved by a post-mortem examination, which showed that, as a result of an illness many years before, there was an adhesion between the stomach, liver, and gall bladder, which suddenly gave way, producing acute peritonitis. Thus closed the earthly career of a most accomplished geologist and naturalist, a broad-minded student of science in general, a successful teacher, an efficient man of practical affairs, and a devout Christian of such delightful personality that he won the regard of every one who came in contact with him.

As so many persons have supposed that professor Wright and I were brothers, it is well to say, at the outset, that we were not, and that our relationship, if any, was so distant that it has not been traced. But twenty-five years of close association with him in college work and much longer general acquaintance had drawn me to him as to a brother, while his judgment in scientific affairs was so sound and unerring that I felt impelled to seek it at every stage of my own work.

Professor Wright was born in Oberlin, Ohio, April 27, 1846, being a son of William Wheeler and Susan Allen Wright, connected, on his father's side, with the family of Orville Wright, and on his mother's with the late professor Frederick Allen of Harvard university. He graduated from Oberlin college in 1865, having served for three months in Company K of the 150th Regiment of the Ohio National Guard, which was called for the defense of Washington in 1864. For two years he taught in the Cleveland institute, when he returned to Oberlin, and, like so many other distinguished geologists, among whom are to be numbered professors J. P. Lesley and Edward Orton, pursued a course of theological studies, two years of which were taken in Union theological seminary, New York City, and the final year in Oberlin seminary, from which he graduated in 1870. For the following two years he filled the chair of mathematics and natural science in Berea college, Kentucky, after which he entered the School of Mines of Columbia college, from which he graduated in 1875. In later years his education was continued in a more general way by numerous extended expeditions into Canada, the Rocky mountains, Florida, and other portions of the Atlantic coast, while the year 1884-85 he spent in traveling in Europe.

On September 21, 1874, he was married to Mary Lyon Bedortha, of Saratoga Springs, N. Y., from which union there is left a daughter, Helen M.; and August 18, 1891, to Mary P. B. Hill, of Flemington, N. J., who with a son survives him.

In 1874 he was called to the chair of geology and natural history in Oberlin college, a position which he filled with complete satisfaction to all for thirty years, to the time of his sudden death. He signalized his connection with Oberlin college by establishing and fostering the laboratory system of study by students in all scientific departments, so that his pupils have shown remarkable facility in their post-graduate studies and in finding entrance to the higher spheres of scientific investigation.

But he accomplished a large amount of work outside of his classroom, as will be seen by the appended list of publications. In 1874 he was engaged upon the second geolo-

gical survey of Ohio to make a report upon the lake ridges of Lorain county. The published results of his work remain the standard source of information concerning that locality. In 1884 he was employed to make the report upon the coal-seams of Holmes county, and in 1893 he was asked to make, for the current volume of the Survey, a report on "The Ventral Armor of Dinichthys," based upon the unique specimens from Lorain county preserved in the Oberlin college museum, in which he demonstrated that what are described by Dr. Newberry as jugulars are really the "companions of his anterior ventrals."

Among the most commendable aspects of professor Wright's scientific work are those which come to light in connection with his practical interest in the affairs of the town and state. Such confidence did his fellow-citizens have in both his attainments and his character that as soon as they contemplated the inauguration of a sewer system and waterworks he was chosen by universal consent to be the leader in formulating plans. After an untold amount of examination of the local conditions, and of study of the subject from every point of view, he presented plans which were accepted, and which, executed under his direction, have secured to Oberlin the model equipment of the state, to which the State Board of Health is constantly referring committees from other localities. All this was accomplished at a minimum of expense to the town. It is also through professor Wright's influence chiefly that the legislature of the State was persuaded to co-operate with the United States geological survey inaugurating a topographical survey of Ohio. His papers, presented to the committees of three different legislatures, and others published broadcast throughout the state, are models both in the statement of the scientific results to be published and of the practical ends to be secured, in order to justify the large appropriations made.

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GENETIC AND STRUCTURAL RELATIONS OF THE IGNEOUS ROCKS OF THE LOWER NEPONSET VALLEY, MASSACHUSETTS. [II.]

By W. O. CROSBY, Boston, Mass.

PRE-CARBONIFEROUS INTRUSIVES.

The earlier or pre-Carboniferous intrusive rocks of the batholite include the following types: granite porphyry, quartz porpryry, felsite and acid andesite. The first three are acid and agree closely in composition, as stated above, with the sedentary types of the batholite, so that they may fairly be regarded as later extravasations from the deeper parts of the same great body of magma. The fourth type, on the other hand, is of distinctly sub-acid or neutral composition, as a partial analysis accompanying Dr. Bascom's description clearly shows. Furthermore, the dikes of this relatively basic type are, according to the rather meagre but quite satisfactory evidence, older than all of the acid intrusives, suggesting eruption from a source below the normal granite and hence during a time (possibly of marked elevation and erosion) when the batholite proper was congealed throughout its entire thickness.

The acid intrusions, on the contrary, including both dikes and necks, may, in the main at least, as previously indicated, be correlated with the subsidence ushering in the sedimentation of Carboniferous times and accompanied by a rise of the isogeotherms sufficiently marked to reliquefy a portion of the ancient acid magma. This correlation is confirmed by the close agreement in composition of the acid intrusions and the normal granite,—for the unquestionable connection of the acid intrusives (both dikes and necks) with the acid effusives or lavas, which rest unconformably upon the deeply denuded surface of the batholite, shows that in origin the intrusions are separated from the sedentary zones of the batholite by a vast time interval during which the magma must have been mainly solid to have escaped marked chemical differentiation.

Acid Andesite Dikes—This is a rock of distinctly neutral composition, anlyses showing from 60 to 62.8 per cent. of silica; and Dr. Bascom's observations indicate a hornblende-bearing biotite andesite. A single dike only has

been studied in detail; but it is known to represent a more or less extensive series, the acid andesite not having been distinguished heretofore from basic andesite and greenstone diabase. This dike begins in the fine granite on Heron street near Washington street and, with a normal breadth of 20 to 25 feet, has been traced northwesterly, parallel with Cottage avenue, into the normal granite and for o total distance of nearly half a mile. It is clearly cut by typical dikes of quartz porphyry and felsite; and the acid andesite occurs as angular inclusions in a great dike of granite porphyry. These relations give it at once a unique position among the basic intrusives of this area and, so far as known, of the Boston basin, by definitely fixing it, chronologically, between the batholite and all of the acid intrusives. Comparison is suggested at once with the more basic, pre-granitic dikes (diabase) in the Cambrian slates of the Blue Hills.* The latter are the only basic dikes in the Boston basin known to be older than the granitic series of the Complex; and the West Roxbury dike just described is the first relatively basic dike in the Boston basin known to be intermediate in age between the sedentary zones and the acid intrusions of the complex.

Granite Porphyry and Quartz Porphyry Dikes.—In this instance, also, the detailed study has been limited to what is, virtually, one large and complex example; but the general conclusions thus reached are definitely known to be applicable to an extensive series of dikes. The fine granite of Bearberry hill in the northeast part of the Stony Brook reservation is traversed in a general northwest-southeast direction by a vertical dike of quartz porphyry 100 feet wide. The greenish gray, aphanitic groundmass of the porphyry is crowded with conspicuous phenocrysts of feldspar up to one-half, and even three-fourths, of an inch in length, while the more scattering, rounded blebs of quartz are commonly one-fourth to one-half inch in diameter. Altogether it is a striking rock and one readily recognized and traced. The quartz porphyry is densely felsitic near the contacts, which are firmly welded, irregular in detail, and further characterized by occasional inclusions of the fine

* Occas. Papers, B. S. N. H., iv, 388.

granite in the quartz porphyry and minor apophyses of the latter in the former.

On this hill, also, the quartz porphyry dike is cut by a four-foot dike of compact and purple felsite, and gives off an oblique branch 20 feet wide, traceable for a thousand feet, and cut by another felsite dike 10 to 15 feet wide.

The phenocrysts of the branch dike are relatively small and inconspicuous, and comparable in size with those of the contact zone; while this contrast between the main dike and its branch proves that in neither case can the phenocrysts be regarded as antedating the intrusion of the magma. On the other hand, the lithologic resemblance of the branch dike to the quartz porphyry phase of the contact zone must be regarded as a mere coincidence, since we have to do in the one case with the earlier phase of the batholite, and in the other with relatively late intrusions cutting, as we shall see, all of the sedentary zones of the batholite from the normal granite to the quartz porphyry.

Southeastward, the main dike is traceable across the reservation boundary and nearly to the Boston-Hyde park line, where it is seen to cut the quartz porphyry of the contact zone and the enclosed masses of Cambrian slate. In the opposite direction from Bearberry hill, across the drift-floored valley of Turtle pond and beyond Washington street, in the large Cottage avenue quarry in normal granite, capped by fine granite, and exactly where the great dike of quartz porphyry might be expected to reappear, we find instead, and with the same trend, a dike of profusely porphyritic granite porphyry, 30 to 50 feet wide. With aphanitic and firmly welded margins, it cuts, clearly and unmistakably, both the normal and the fine granite; and it is, in turn, cut squarely across by a small dike (2 to 4 feet) of felsite in which the fluxion structure parallel with the irregular walls is beautifully developed. Apparently, there is no reason to doubt that this intrusive granite porphyry which Dr. Bascom regards as essentially identical in composition with the normal granite, is also simply a more crystalline phase of the intrusive quartz porphyry, the two rocks being part of one and the same continuous dike; and facts yet to be noted abundantly confirm this conclusion.

The next outcrop of this dike, where it crosses Heron street, is also granite porphyry; but beyond this the quartz porphyry phase recurs, and the dike, now 75 feet wide, is lithologically indistinguishable from the Bearberry hill section. From this point on, it is near to and approximately parallel with the dike of acid andesite previously described; and the latter is cut by minor dikes or apophyses of quartz porphyry. The outcrops of both dikes are now interrupted by a swamp, beyond which the dike of acid andesite continues unchanged, while the porphyry dike, now 80 feet wide, is once more a typical granite porphyry, apparently repeated by an oblique strike fault and, as previously noted, enclosing angular fragments of the acid andesite. Thus twice in a total distance of a little more than a mile, the quartz porphyry gives way to granite porphyry. In neither case, unfortunately, can the transition be fully traced; and yet we may not reasonably doubt its reality. This remarkable and rhythmic textural variation in the contents of one and the same continuous fissure may, perhaps, be regarded tentatively as finding its most natural explanation in varying original depths of solidification. That is, if we may assume a natural gradation upward in the dike from granite porphyry to quartz porphyry, then a moderate amount of subsequent displacement, or even of unequal erosion, might suffice to give the alternations of texture which the outcrops now show. In this connection it may be noted that in the lowest outcrop of the main dike, at the western base of Bearberry hill, the quartz porphyry is well advanced in the change to granite porphyry. It is a fair corollary of this explanation that the granite porphyry should be found chiefly in the normal granite, and the quartz porphyry in the fine granite. This relation is clearly realized in part; and would, perhaps, be more fully realized, but for the fact that, as we suppose, the batholite suffered strong and unequal erosion before its injection by these acid intrusives.

Felsite Necks.—Besides its abundant occurrence in effusive forms or surface flows, the devitrified rhyolite (aporhyolite) or felsite has an important development in necks and dikes, which are undoubtedly contemporaneous

with the acid effusives; and nowhere, apparently in the Boston basin, are normal effusives more clearly or typically developed. Some of the felsite dikes are large enough to be regarded as the vents of effusive masses; and very probably several of them are deeply denuded necks. The more typical and unequivocal necks, however, are less dike-like in outline and far more diversified in structure, consisting chiefly of clastic lavas—agglomerate and tuff—suggestive of explosive eruptions toward the end of the volcanic activity and following more quiet liquid effusions. Three essentially distinct vents have been more or less fully worked out; and it is considered not improbable that others await recognition in the felsite areas. This appears the more likely in view of the fact that acid lavas of fluidal and autoclastic types, that is, lavas which were stiff enough at the time of their effusion to develop fluxion lines, or even to become brecciated by their own flow, would not spread far from the vents through which they reached the surface. We must recognize also the extreme probability that some vents are still concealed by their own sluggish effusions or by later sediments. The three vents referred to as more or less fully identified are near the heart of the complex and bordered either wholly or in part by the sedentary zones of the batholite, including the normal granite, fine granite and quartz porphyry; and evidence is not wanting that they are, in each case, located on important displacements, one indication of this relation being elongation in a definite direction, the outlines being distinctly lenticular.

The West Roxbury Neck.—This neck is the most clearly exposed in outline and in structural detail, and probably the largest, as it is certainly the most indubitable of the series. It occupies approximately the irregular triangular area bounded by Grove, Center, Stimson and Washington streets in West Roxbury, near the Dedham line.

It is elongated in a general northwest-southeast direction, the extreme dimensions being approximtaely 1200 by 3500 feet. The major axis coincides in position and trend with the common boundary of the fine granite and the western area of normal granite, the evidence being quite conclusive that this line marks an important displacement.

The sharp definition of this neck, with its continuous rim of granite, is, of course, chiefly due to the fact that erosion has removed the last vestige of the effusive felsite which we must assume to have once covered its site and a wide area of the enclosing granites.

Not to classify this sharply defined body of acid lavas as a true neck or vent would seem to necessitate regarding it as a depressed fault block or graben, a remnant of a once widely extended volcanic sheet covering the granites which has escaped erosion through the accident of displacement. But the varied and prevailingly clastic character of the lavas and the general structure of the mass are, at least, highly suggestive of a vent, and force the conclusion that there must be a vent somewhere in this part of the complex. Although, omitting intersecting dikes of felsite, andesite and diabase, the neck is almost wholly composed of effusive types of felsite; it is yet, quite independently of the dikes, highly diversified in composition and structure—a constantly varying complex or chaos of fragmental, fluidal and compact or structureless lavas. The clastic phase, ranging from the finest tuff to the coarsest breccia or agglomerate, largely predominates and gives character to the whole, leaving little room to doubt that the later eruptions, at least, from this vent were in part explosive. Although varying greatly in azimuth and inclination, and usually much contorted, the normal attitude of the flow structure of the felsite is parallel with the axial plane of the neck, or, in the peripheral portions, with the proximate wall of granite. The interest of the peripheral phenomena culminates in the southeastern extremity of the neck, where it is continued in the shattered zone of granite in which it had its origin as a complex of granite and felsite, the granite being cut in all directions by irregular branching and coalescing dikes of the felsite, which is brecciated, banded, compact or porphyritic by turns and encloses many large and small angular fragments of the granite.

While we need not doubt that the fragmental lavas are, in the main, true pyroclastics, the product of explosive eruptions, it is very probable that they are in part autoclastics, or breccias resulting from the continued movement

of the magma after it began to stiffen and solidify. The distinction of these two types in the field must usually be a puzzling matter, so much depending on the nature of the matrix or ground mass; but it is assumed here that local homogeneity of composition (not of texture) and absence of granitic debris are characters belonging more normally to the autoclastics. In considering the distinction and probable relative abundance of the pyroclastic and autoclastic lavas, both of which are undoubtedly prominent features of this neck, and may also be designated, respectively, agglomerate and breccia, we may properly take account of the possibility that the eruptions were subaqueous, at least in part, and note the cracking and shattering of the lava that would follow its sudden quenching. It is doubtful, however, if much of the breccia has the crackled character, with accurately fitting fragments, which this explanation would require. Nevertheless, the presence of water is plainly suggested by the rather distinct stratification of some of the finer tuffs, such as may be observed in the central part of the neck especially.

Attention is thus directed to one of the most interesting and puzzling features of the neck. This is a very compact gray, slaty-looking rock, irregular masses of which are enclosed in the more normal or unquestionable agglomerate and also in the fluidal felsites and occur only in the western central portion of the neck, all the outcrops being included within an area about one thousand feet long in a north-south direction and perhaps half as wide. This material, which may be as distinctly, evenly and finely, or as obscurely, stratified as any slate, was at first mistaken for an older slate enclosed in the volcanics. But further study of the field relations showed that it must be contemporaneous and essentially a tuff or consolidated ash. As noted by Dr. Bascom, this conclusion is confirmed by both the microscopic and the chemical analyses. The combined alkalies are far higher than for a normal slate and agree closely with those of the felsites. These masses range in extent from a few inches to many feet. They are sometimes ill-defined, cloud-like patches in the lavas; but more commonly they are sharply outlined and the contacts with

the felsite are unquestionably igneous, being firmly welded and the sediment well baked for a breadth of one to several inches. Even closely adjacent masses do not usually agree in dip and strike; but the relations are what might be expected in the case of a bed or beds of imperfectly consolidated ash disturbed by later eruptions, largely of an explosive character. The close relation of the consolidated ash or slaty tuff to the felsite agglomerate is clearly indicated in some instances by the intercalation of visibly clastic layers. Finally, we may regard the ash as the finest product of an explosive eruption which was in some sense subaqueous, closely followed by eruptions which were only in part of an explosive character, yielding, besides the true agglomerates, compact, fluidal and autoclastic felsites intersecting and enclosing, alike, the agglomerate and the ash.

Accepting the West Roxbury neck as a true volcanic vent, as apparently we must, it may be assumed to have originated in a more or less complex and branching fault fissure; and the local widening of such a fissured zone to the present breadth of the neck when it finally became the locus of vulcanism would be a natural consequence of the explosive action of which we have such ample evidence. In other words, we need not assume that the granite was melted away, or forced out en masse, Pelée fashion; but it is sufficient to assume a splintering and shattering of the granite walls under the influence of shock and heat. The resulting granite debris would be borne upward by the constantly increasing volume of viscous lava made possible by the widening of the vent, and finally discharged, largely through the agency of violent explosions. This explanation, the essence of which is a gradual crumbling and exfoliation, accompanied by cracking and rending of the granite walls of the primordial fault fissure, accounts for the general diffusion of granitic detritus through the clastic lavas, as well as for larger, isolated masses of granite which now add to the diversity of the neck.

The Hyde Park Neck.—This large and composite neck occupies a more central position than the West Roxbury neck in relation to the complex; and presents some other distinguishing features. It is, probably, best regarded, in

detail, as two necks developed on fissures, approximately parallel with the major axis of the West Roxbury neck; but converging irregularly northwestward, near the Cambrian outliers; and the united axes might be regarded as continued in the great dike of quartz and granite porphyry. Where most widely separated and most distinctly developed as necks, these fissures are clearly compensating displacements bounding a depressed area approximately half a mile wide.

The southwestern fissure, designated the Bold Knob neck, shows a wall of the massive quartz porphyry of the contact zone bordered on the northeast by several hundred feet in breadth of coarse felsite agglomerate, the felsitic matrix of which is packed with large, angular fragments of both felsite and quartz porphyry. Northeastward, or away from the wall of quartz porphyry, the agglomerate becomes rapidly finer and shades off into fluidal, spherulitic and other obviously effusive forms of felsite. Similarly the northeastern fissure, known as the Grew's Woods neck, shows an immense mass of exceptionally coarse agglomerate sharply limited on the northeast by normal granite. The agglomerate has a maximum breadth of nearly a thousand feet, passing gradually, as before, into the effusive felsites, which are continuous over the area intervening between the two bodies of agglomerate. Not only has the effusive felsite discharged by flow and explosion from these fissures overspread the depressed area which they bound; but from this expanding area, as from a cornucopia, the felsite flows have spread eastward over a large part of Hyde Park and into Dorchester and Milton. Unlike the West Roxbury neck, and on account of the general eastward inclination of the geological structure of the district, erosion has not cut deeply enough to remove entirely the effusions of this most eastern of the recognized felsite necks.

Felsite Stocks.—Besides the large and essentially indubitable necks of acid lava described in the preceding pages, we must, as previously noted, recognize several more or less probable stocks or plugs of felsite in the sedentary zones of the batholite. These masses, which may, perhaps,

best be regarded as more deeply denuded as well as smaller necks, are intermediate, in size at least, between the undoubted necks and the normal felsite dikes. They are related to the necks in form and to the dikes in lithologic character, lacking entirely the clastic and fluxion characters and the general structural heterogeneity of the necks. One difficulty in regarding them as dikes is that they do not appear to occupy dynamic fissures, being chimney-like rather than dike-like in form. The clearest examples are roughly circular or elliptical plugs 200 to 300 feet in diameter, isolated in, and enclosing numerous fragments of, the normal granite. The rock, although felsitic in general aspect, is, perhaps, better described as a dense, non-porphytitic microgranite. It is essentially homogeneous and structureless, except for an indistinct peripheral zone of true felsite, in part fluidal.

Felsite Dikes.—In the general view the entire area of the complex appears to be traversed by dikes of felsite. They are, however, especially characteristic of the sedentary zones of the batholite and the felsite necks, and are observed less commonly in the effusive felsites. In spite of the fact that they sometimes cut both the felsite necks and flows, the dikes, as a whole, are undoubtedly best regarded as essentially contemporaneous with the acid volcanics, and we may fairly suppose that in some instances they have formed effective vents. We have seen that they intersect the great dikes of quartz porphyry and granite porphyry; but here, again, an important difference of age is not, apparently, a necessary inference. The relation of the felsite dikes to the necks is in some cases distinctly radial; but a broader view shows that with few exceptions they tend to be normal to the major axes of the felsite necks and the fracture zones in which the necks have been developed. The prevailing trend, therefore, is northeasterly and southwesterly.

In the extension of the axial shear zone of the West Roxbury neck, the felsite forms a plexus of irregular intrusions, which branch and coalesce in a quite remarkable way; while the true dikes represent the filling of comparatively simple and sharply-defined transverse fissures due,

perhaps, to torsional stresses accompanying the shearing.

The felsite dikes range in size up to a hundred feet or more; and they can be traced in some instances for a good fraction of a mile; but the correlation of individual outcrops is often difficult because of marked irregularities of form and trend. As described by Dr. Bascom, the felsite of these dikes is mainly either densely compact or, more commonly, inconspicuously porphyritic. In general, and as might naturally be expected, the larger dikes have porphyritic centers and nonporphyritic or compact borders; while the smaller dikes are often nonporphyritic throughout. With few exceptions, the peripheral portions of the dikes exhibit more or less distinct, and often very marked, fluidal structure parallel with the walls; and the smaller dikes may be characterized by the fluxion lamination through their entire thickness. The large dikes, also, are usually dark red or purple in the middle portion and greenish gray along the borders; while the small dikes are commonly gray across the entire section. It appears probable that the normal original color of the felsite was gray, that it was subsequently reddened by oxidation and later bleached by deoxidation and leaching along the borders. The greenish color of the periphery is, however, according to Dr. Bascom's observations, to be connected, in most cases at least, with a more or less marked epidotization, often followed by hydration and the development of pinite; and not infrequently a border of nearly pure, soft, green pinite has resulted.

PRE-CARBONIFEROUS EFFUSIVES.

Effusive Felsite or Normal Aporehyolite—The acid effusions of the vents described in the preceding sections, and, doubtless, of other vents still entirely concealed by the effusives, probably constitute for the Neponset valley, a more or less continuous sheet of lava chronologically and stratigraphically intermediate between the denuded surface of the batholite and the Carboniferous sediments and distinctly unconformable in its relations to both. The petrographic and chemical characters of the effusive felsites have been fully described by Dr. Bascom. The original textural variations are most notable, including compact, fluidal, spherulitic, and clastic forms. Although the surface ex-

posures are numerous and instructive, by far the most complete section of the felsites was that afforded temporarily during the construction of the Stony Brook-Neponset tunnel, nearly a mile long, of the High-level sewer. This shows the felsites resting upon both the normal and fine granites at points remote from the nearest surface exposures of these rocks. The flow structure of the felsites, originally horizontal, is now everywhere highly inclined and chiefly vertical, showing that the plication of the Carboniferous sediments was shared by their volcanic floor. As to the original or normal thickness of the acid effusives of the Neponset valley, we have no reliable data; but it was quite certainly to be measured by hundreds and probably not by thousands of feet.

CARBONIFEROUS VOLCANICS.

The volcanic rocks definitely known to be contemporaneous with the Carboniferous conglomerate of the Neponset valley include a moderately acid type—trachyte, and a moderately basic type—andesite. The andesite largely predominates; but the trachyte is, in the main at least, the older and may, perhaps, be regarded as in some sense a transition type between the felsite and andesite.

Apotrachyte.—As described by Dr. Bascom, this is a coarsely and profusely porphyritic rock of highly feldspathic composition, with albite as the predominating feldspar. Dr. Bascom shows that the chemical analysis of this rock confirms its classification as a soda-trachyte in which diopside must have been an original constituent; or, having regard for its present altered condition, it may be more precisely defined as a soda-apotrachyte. This rock has been recognized as forming one small flow conformably interbedded with the conglomerates of the Central Avenue district in Milton, and a probable vent, in part of agglomeratic structure, on the New England railroad north of River street, Hyde Park. The latter occurrence was intersected and more fully exposed by the Stony Brook-Neponset tunnel.

Apoandesite.—This important volcanic is described by Dr. Bascom as an aphanitic rock of dark purplish and greenish tints in which the original constituents are mainly altered to calcite, chlorite, epidote, quartz and other second-

ary species. The microstructure is commonly trachytic and inconspicuously fluidal and porphyritic; and the effusive phases are often amygdaloidal or clastic. The distinguishing feature, chemically, as for the trachyte, is found in the high percentage of soda; and the extensive mineralogic alteration, without obliteration of original structures, makes this, therefore, a normal soda apoandesite.

In areal extent and structural value the Carboniferous andesite is comparable with the pre-Carboniferous felsite; and like the felsite, it is found in the three general modes of occurrence—necks, dikes and flows. The bedded lavas, both acid and basic, of the Neponset valley are believed to be exclusively contemporaneous.

The andesite dikes are very numerous; and they are found in all parts of the complex—cutting the successive zones of the batholite and its cover of acid lava (felsite), and cutting also the acid dikes of various types, including the porphyry dikes, and the necks, stocks and dikes of felsite. In distribution, trend, form and size they are comparable with the felsite dikes; and the profusion of the basic dikes clearly indicates a very general and extensive fissuring of the subcrust during the subsidence which permitted the deposition of the Carboniferous conglomerate.

It is not improbable that some of the andesite dikes have formed effective vents. But of unequivocal or normal necks there are no indications in the sedentary zones of the batholite or in the vicinity of the felsite necks; but they are to be found farther east, in the effusive felsites, the clearest examples occurring on either side of the Neponset, in the Mattapan district of Dorchester and the Columbine district of Milton. These vents are decidedly elongated or fissure-like; but they are readily distinguished from the andesite dikes by even greater irregularity of outline and especially by the heterogeneity of structure and the prevalence of coarsely clastic or agglomeratic lava. The evidence is quite as clear as for the dikes that the andesite is younger than the effusive felsites.

The andesite flows, like the dikes, are chiefly aphanitic, but embrace, also, amygdaloidal and scoriaceous forms; and in the western part of the field, especially, bedded tuff and

agglomerate, the product, probably, of explosive submarine eruptions, are prominently developed. The contemporaneous relation of the effusive andesite and the conglomerate is especially clear for these fragmental varieties; but hardly less so for the regularly interbedded flows in the Central avenue and other parts of the field. The transverse sections of individual flows are, in some instances, very instructive, showing a normal gradation upward from densely aphanitic to amygdaloidal and scoriaceous forms of lava.

DIABASE DIKES.

As previously intimated, the diabase dikes of this area, as of the Boston basin generally, are referable to two distinct series—distinct in age, trend and lithologic character. We may properly emphasize the chronologic distinction, as of greatest geologic significance, by designating these two series, provisionally, the Carboniferous and the Triassic. Evidently, the diabase dikes are not related in origin or composition to any of the other igneous rocks of the district; and in size, regularity and continuity the two systems are essentially similar and normal.

Carboniferous Diabase Dikes - The normal trend of the numerous dikes of this series is approximately east-west; and they rarely vary more than thirty degrees from the normal. Although commonly approximately vertical, they are more likely than the Triassic dikes to exhibit a distinct hade, especially in the sedimentary terranes, the manifest tendency being to conform with the strike joints of the enclosing formation. In other words, these are longitudinal dikes, traversing a series of unsymmetric folds, and sympathizing in attitude with the tension planes of the flexures, having been developed during a period of folding and strike or thrust faulting. In the dikes of this series transverse columnar jointing is rarely distinctly developed. Lithologically they are rather fine-grained greenstones, the original or normal constituents having suffered extensive chloritization and epidotization, in consequence of which the diabase is somewhat immune to kaolinization and to be reckoned among the more resistant rocks of the region.

Triassic Diabase Dikes—The rather infrequent dikes of this series adhere very closely to a north-south trend and

vertical attitude, a hade of even a few degrees being very unusual. Their relation to the general geological structure of the region is distinctly transverse; and, evidently, they date from a period of gravity faulting without folding, such as the Triassic is known to have been. Transverse columnar jointing is commonly well developed; the greenstone alteration is wanting; and the rock yields readily to kaolinization, the tendency to pass by spheroidal weathering to a rusty brown earth being a marked feature of this diabase.

STRATIGRAPHY OF THE EASTERN OUTCROP OF THE KANSAS PERMIAN.*

By J. W. Beede and E. H. Sellards.

PLATES IV-V.

According to Prosser† and Frech‡, the Wreford limestone may be considered the base of the Kansas Permian. The writers' studies are at present confirmatory to this view. From a geographic standpoint this is a most fortunate occurrence as this limestone forms one of the most striking and persistent escarpments in Kansas. It is the most easily mapped formation in the state with the possible exception of the Florence flint, sixty feet above it. The northern two-thirds of the outcrop has already been worked out and discussed in greater or less detail, and is fairly well known, but this can hardly be said of the southern third. The object of the present paper is to give a generalized map of the outcrop, so far as determined, and to furnish an idea of the stratigraphy, throughout the length of the strike in Kansas—a distance of over 200 miles while the extent of the outcrop is several times as great.

NATURE OF THE OUTCROP.

In the region north of the Kansas river the escarpment formed by the Wreford limestone is frequently fainter than that of the Florence flint and Fort Riley limestone. This is true of most of the Blue river region north of Garrison. The Cottonwood limestone escarpment is subordinated in

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† Jour. Geol., x, pp. 709, 710, 721-724, 1902.

‡ Lethaea Palaeozoica, II, Lief. 2, p. 378, &c, 1899.

the northern third of its outcrop where the Wreford limestone and Florence flint appear in the same bluffs, as in some localities in the Blue river region. However its outcrop is always strongly marked when it is found at considerable altitudes above drainage level or well removed from the flints, as at Manhattan, Frankfort, Alma, etc., except when deeply drift covered as near Summerfield.

In the central region, from the Kansas river south to the vicinity of Reece, the Wreford limestone is best developed and forms a very strong escarpment with the Florence flint forming another just above and west of it. Throughout this region as far south as Bazaar, Chase Co., the Cottonwood limestone escarpment retains its sharp outline and whitish appearance. For the entire distance from the Nebraska line the Cottonwood limestone retains its striking peculiarities which are so distinct that even an amateur would not overlook it. The same may be said of the Florena shale lying upon it. South of the latitude of Bazaar both these layers lose their distinctive characters and cease to be of great importance as horizon markers. Whether or not they extend across the southern part of the state as distinct strata can only be determined by carefully tracing them the entire distance. In the southern region, except, perhaps the southern fourth of it, the Wreford limestone escarpment becomes somewhat accentuated, where it actually reaches the crest of the ridge. This is due as much to the drainage as to the relative importance of the stratum which is really thinner here than it is farther north. At Beaumont and Grand Summit it has been removed from the top of the escarpment. At the former place it occurs at the front of the ridge some distance north and south of the railroad but falls back to the middle of the town and is lower in altitude than the railroad grade at the crest of the escarpment on account of the westerly dip of the rocks. This is more strikingly the case at Grand Summit where the Wreford limestone and some ninety feet of underlying rocks have been removed along the railroad as far west as Grouse creek, west of Cambridge. About two miles north of Grand Summit it appears in the top of the escarpment and also forms a high ridge west of the town,

as will be noted later. South of this region local structures come to be of some importance and the stratigraphy has not been worked out in detail. Just east of Dexter it may be seen dipping sharply into the ground to the eastward while the general dip is to the west.

As far south as Reece the Florence flint reaches nearly to the edge of the escarpment forming a second prominent bench. South of this it becomes, frequently, less distinct—except in the region of Burden, and comes in in the back-slope toward the Walnut river forming a second escarpment. It is impossible to locate the Cottonwood limestone with certainty here by its lithologic or other characters. All the limestones of any considerable importance are excellently shown in the numerous cuts and exposures but none of them possess the typical appearance of the Cottonwood. The writers are of the opinion that it is continuous with changed lithologic characters throughout this region, but this is by no means certain. It has never been traced to the southern limit of Kansas and "into Oklahoma" by any Kansas geologist.* The statements of Keyes were probably based on Haworth's reconnaissance map published in the first and second reports of the Kansas survey,† which was probably based on Adams' section from Galena to Wellington.‡ If the Cottonwood limestone extends this far south the map mentioned is not much in error as to its general location. On this map the Cottonwood limestone is marked as the upper limit of the Coal Measures and the rocks above are indicated as Permian in accordance with Prosser's earlier opinion.§

The outcrop of the Florence flint and Fort Riley limestone closely parallels the outcrop of the Wreford limestone across the state and could be represented in a general way by a line close to the line on the accompanying map, but lying just west of it. The same would be true of the Cottonwood limestone as far south, or a little farther, than the latitude of Emporia but lying just east of the Wreford limestone. In such places as Manhattan, Frankfort, and Mill

* Keyes, Amer. Geol. xxiii, pp. 308 and 311.
† Univ. Geol. Surv. Kans., I, pl. xxi, 1896; II, pl. xlviii, 1897.
‡ Op. Cit., I. pp. 16-20, 1896.
§ For the original classification and the references to the literature see, Jour. Geol., III, pp. 682-705, 764-800 and especially chart p. 800, 1895: For revised classification see Ibid. x, pp. 703-737, 1902.

creek, in Wabaunsee county, there would be some error in the latter statement, but in general it would be true.

DETAILS OF STRATIGRAPHY.

In order to give a clear idea of the stratigraphy of this horizon throughout its great extent of outcrop it will be necessary to discuss each of the several associated formations and give detailed sections of well distributed exposures.

As already stated the escarpment of the "Flint hills" (formed by the Wreford limestone, Florence flint and Fort Riley limestone) is so marked a feature that it may be traced across the state without difficulty. Quite as striking still is the great uniformity of the formations associated with the escarpment.

Northern province: In 1858 Henry Englemann passed over this region and briefly discussed the rocks, probably in the vicinity of Frankfort and Marrett.* In 1881 Broadhead published a paper on the "Geology of the Central Branch railroad"† giving sections, particularly at Frankfort. These papers are discussed by one of the writers in the Kans. Univ. Quart., IX, pp. 191-202. In 1895 Knerr ran a section over the same route.‡

The Nebraska area has been pretty thoroughly discussed by Knight.§ The writers have been over the Blue Springs (=Wymore), Nebraska area and studied his sections in a general way. According to Knight's section the thickness of the Florence flint in the bluffs opposite Blue Springs, numbers 5 to 7 of his section, is 19 feet 2 inches, with 13 feet, numbers 8 and 9, of the Fort Riley limestone exposed above it. At the Crusher quarry, near the B. and M. R. R.—U. P. junction south of Blue Springs we measured the section of the Florence flint, finding it to be 19 feet 6 inches with a four foot layer of limestone beneath. Including this limestone, which was not included in the flint in Knight's section, the total thickness would be 23 feet 6 inches. This lower layer is somewhat fossiliferous. Just north of the junction beneath the U. P. bridge over the little

* Simpson, Expl. Exped. Gt. Basin, Utah, p. 254, 1859.
† Kans. City Rev. Sci. and Ind., V, p. 119 et seq.
‡ Univ. Geol. Surv. Kans., I, pp. 140-144, 1896.
§ Jour. Geol., vii, pp. 357-374.

creek the Wreford limestone is exposed. The interval between this outcrop and the base of the Florence flint, in the Crusher quarry is 61 feet, barometrically. This interval represents the thickness of the Matfield formation at this locality, with, perhaps, some of the upper part of the Wreford limestone.

(For the description and definition of the formational terms used in this paper see the two papers of Prosser previously cited and Folio 109, U. S. Geol. Surv. Atlas. It is also necessary to call attention to Adams' paper, Bull. 211 U. S. Geol. Surv., 1903, in which these formations were discussed and given the names proposed by Prosser in the latter of the two papers referred to which appeared about 10 months prior to Adams' paper. Consequently Adams' statements concerning the Elmdale, Eskridge, Matfield and Doyle formations, pp. 54-59, that "It has not heretofore received a distinct name" etc. etc. are in error. More lamentably so because from his own statement to me he was thoroughly cognizant of Prosser's paper for months before his paper was published.—Beede.)

Owing to an anticlinal structure north of the Kansas line the Wreford limestone appears at the B. and M. R. R. junction as just mentioned and is somewhat fossiliferous. The section beneath the U. P. bridge is as follows:

4.	Chert, a fourteen inch layer	1 ft. 2 inches
3.	Limestone, irregular and rather thin bedded	3 " 0 "
2.	Shales, hard buff	3 " 0 "
1.	Shales, blue, extending to the creek bed	2 " 0 "
	Total	9 ft. 2 inches

Numbers 3 and 4 probably represent the upper part of the Wreford limestone and are somewhat fossiliferous while 1 and 2 are probably interbedded shales with the major part of the limestone below.

At Holmesville (not visited by the writers) a little over 20 feet of limestone, according to Knight's section may be referred to the Wreford, the lower six feet of which is cherty.* The section at the state line was not visited by the writers but according to Knight's section there are 35 feet of Matfield shales, numbers 1 and 2 of his section,† and apparently 15 feet of Florence flint, number 3. However it seems probable that number 4 of his section contains about two feet of cherty limestone belonging to the Flor-

* Op. cit. p. 368.
† Loc. cit. p. 367.

ence flint. Numbers 4 to 7 represent the Fort Riley limestone, of which 33± feet are shown in the section. In Beede's section at Oketo‡ the top of the Matfield is shown in the ravine just north of the depot. The thickness of the Florence flint is given as 17 feet and the total thickness of the overlying Fort Riley limestone is given as 37 feet.

Passing down the Big Blue river to Marysville we find the same general conditions repeated. In the northern part of the town 11 feet of the top of the Matfield formation followed by 20 feet of the Florence flint and 26 feet of the Fort Riley limestone are exposed, as shown in the following section:

MARYSVILLE SECTION.

10.	Limestone, thin bedded, disintegrated	2+ ft.	0	inches
9.	Limestone, brownish with fragments of pelecypods	2 "	6	"
8.	Limestone, thin bedded, light colored grading into shale	3 "	9	"
7.	Limestone, cellular, with iron streaks and stem-like marks	3 "	9	"
6.	Limestone, cellular	5 "	0	"
5.	Marls and clayey shales with brachiopods and bryozoans	9 "	0	"
4.	Limestones with layers of chert and chert concretions, including a two foot layer of soft limestone below the chert. Aviculipinna at the top of the flint	20 "	0	"
3.	Shale, soft, gray and fossiliferous	0 "	6	"
2.	Limestone	2 "	6	"
1.	Shales, red and blue, carbonaceous in places, with plants	8 "	0	"
	Total	57 ft.	0	inches

Numbers 1-3 belong to the Matfield formation, number 4 is the Florence flint and 5-10 are classed with the Fort Riley limestone.

Number 3 is a quite fossiliferous calcareous shale as is number 5. The latter seems to be more nearly related to the Fort Riley limestone lithologically, that is, it seems to grade into the limestone laterally more than into the flint, and is classed with it. Bryozoa and Brachiopods are the dominant fossils of this layer. The individual layers of the

‡ Paper cited above.

Fort Riley limestone show a tendency to pinch out, or to be lenticular as is shown in the Marysville and Oketa quarries but it has no effect on the thickness of the stratum as a whole.

There is an excellent exposure of the lower Permian rocks, ranging from the upper part of the Wreford well into the Fort Riley limestone, on the west side of the Big Blue river three miles south of Marysville where the bottom road crosses a bridge over a little creek. The section begins at the river level and passes up the creek beneath the bridge to the top of the high, bare-faced bluff above the bridge. At this point the Wreford limestone passes beneath the Big Blue river, causing a slight fall.

SECTION AT BRIDGE ACROSS CREEK THREE MILES SOUTH OF MARYSVILLE ON THE WEST SIDE OF THE BIG BLUE RIVER.

28.	Limestone	5+	ft.	0	inches
27.	Covered	10	"	0	"
26.	Limestone, shaly	3	"	0	"
25.	Limestone with fossils and a little chert	2	"	0	"
24.	Shales, yellow, with fossils	1	"	6	"
23.	Limestone with 3 to 4 layers of concretionary chert	3	"	4	"
22.	Shale, calcareous, or marl	0	"	9	"
21.	Limestone with thin chert layer below and 4 inch layer in upper part	2	"	0	"
20.	Limestone with 7 layers of concretionary chert	5	"	6	"
19.	Limestone with 4 layers of concretionary chert	4	"	0	"
18.	Shales, fossiliferous, = layer below flint at Marysville	0	"	6	"
17.	Limestone, argillaceous	3	"	0	"
16.	Shales, red and green with sandstone layer	14	"	0	"
15.	Sandstone, soft red	1	"	3	"
14.	Shales, clayey, blue, olive and green	19	"	0	"
13.	Limestone, blue	1	"	0	"
12.	Shales, blue clayey	3	"	0	"
11.	Talus, by barometer	25	"	0	"
10.	Shales, green, showing in creek bank	1	"	6	"
9.	Covered, creek bed	3	"	0	"
8.	Limestone, gray clayey	2	"	0	"
7.	Limestone, very compact with smooth fracture, solid geodes	1	"	0	"

6.	Limestone, very dark blue argillaceous.......	5 "	0	"
5.	Limestone, 6 inches to 1 foot, with fragments of fossils beneath bridge	1 "	0	"
4.	Chert, 5 inches to..........................	0 "	6	"
3.	Limestone, blue with fragments of fossils.....	0 "	6	"
2.	Chert	0 "	4	"
1.	Limestone, thin layers below high water at the mouth of the creek. Farther out in the river a layer of chert may be seen at low water	? "	?	"
	Total	118 "	8	"

Numbers 1 to 8 represent the upper part of the Wreford limestone, a total of over 10 feet 4 inches. The section covered by the high water in the river at the time of our visit should be added to this in estimating its thickness at this exposure. Numbers 9 to 16 are the layers of the Matfield formation which has an aggregate thickness here of 67 feet 9 inches. Numbers 17 to 23 represent the Florence flint with a thickness of 19 feet. There are 21 feet 6 inches of the Fort Riley limestone, numbers 24 to 28, exposed at the top of the section.

On the side of the hill west of Marysville the Florence flint and Fort Riley limestone have a combined thickness of about 60 feet. Resting on the limestone are 20 feet of red, blue, green and yellow shales followed by a comparatively thin limestone. The remainder of the hill is covered to the top, a distance of about 40 feet. The base of the Winfield limestone should be found here but no traces of it were noticed.

In eastern Marshall county, near Beattie, the Cottonwood limestone is eight feet thick, the lower part being impure. At this locality the Florena shales are only two feet thick.* Above this are exposed ten feet of argillaceous limestones and indurated calcareous shales of the lower part of the Neosho member of the Garrison formation. Going west along the railroad from the outcrop of the Cottonwood limestone to what appears to be the Wreford limestone shown in the cut near milepost 102 on the Grand Island R. R. the barometer showed a rise

* Numbers 1 to 3 are the Cottonwood limestone, and 4 is the Florena shale. Kans. Univ. Quart., ix, p. 195.
* Kans. Univ. Quart., ix, p. 196.

of 70 feet. Allowing for the probable dip would give the Garrison formation a thickness of 110 feet in this vicinity.

Since it was necessary to select another term than the "Cottonwood shales" for the shales immediately above the Cottonwood limestone the term "Florena shale" was used† because of the extensive quarries in the Cotonwood limestone at Florena which show the shale admirably, rich in its typical fauna, though somewhat diminished in thickness when compared with the Cottonwood Falls region. The section at the Florena quarries is as follows:

FLORENA QUARRY SECTION.

5.	Limestone, extremely thin bedded, and shale	3 ft.	0	inches
4.	Limestone	2 "	0	"
3.	Shale, calcareous with abundant fossils, the Florena	3 "	8	"
2.	Limestone, nearly white with small Fusulinæ	2 "	2	"
1.	Limestone, the upper third with many Fusulinæ	5 "	6	"
	Total	15 ft.	4	inches

Numbers 1 and 2 are the Cottonwood limestone and number three is the Florena shale. Numbers 4 and 5 are the base of the Neosho member of the Garrison formation. The Florena shales thicken to the southward, from two feet at Beattie to 3 feet 8 inches at Florena. This thickening continues to the Cottonwood river where they reach a thickness of 6 feet.

Southward from Florena, in the vicinity of Garrison, the Cottonwood limestone passes down to about, or a little below, the level of the river. Here the Garrison formation, Wreford limestone, Matfield formation, Florence flint and Fort Riley limestone all take part in forming the picturesque bluffs of the Big Blue river. It may have been from the inspiration of this place that Cragin named the lower Permian rocks of Kansas the "Big Blue Series."* There are 82 or more feet of the Garrison formation exposed in the bluffs by the town. The Wreford limestone has a

†Prosser, Revised classification of the upper Paleozoic formations of Kansas, Jour. Geol., x, p. 712 and the table of formations opposite page 718. See note on p. 737, where the "Cottonwood limestone" is retained and "Alma limestone" is dropped.

* Colorado College Studies, vi, p. 5, 1896.

thickness of somewhere from 30 to 45 feet (can not be well determined from the face of the bluff), and the Matfield formation has a thickness of about 70 feet. The Florence flint is about 20 or 25 feet thick and the Fort Riley limestone is about 40 feet.

According to our figures the total thickness of the section in the hill at Garrison is 300 feet. One of the writers was informed that the bluff had been measured by transit and level and found to be 268 feet above the town. Our section includes the higher hills to the north of the flag pole, which, probably, were not included in the measurement just referred to.

About a quarter of a mile west of the Garrison junction Beede gives a section of fifteen feet of the base of the Wreford limestone.* A mile farther west he gives another section beginning somewhat above the Wreford limestone and continuing into the Fort Riley limestone.† Number 1 of this section should read 25 feet instead of 20 feet, making the total thickness of the section 98 feet, divided as follows: Matfield formation 51 feet, Florence flint 22+ feet, with 21 feet of the Fort Riley limestone exposed.

This general survey gives an idea of the stratigraphy of the lower Permian and associated rocks north of the Kansas river. These rocks from Manhattan and Junction City southward to the Cottonwood river have been made familiar to the geological public by Prosser and Hay and only some of the salient points will be mentioned to bring them clearly to the reader's mind.

Central Province.—At Manhattan, Prosser gives the thickness of the Cotonwood limestone as five feet,* and at Alma five and one-half feet. West of Manhattan, along the Kansas river the higher formations appear. Prosser† reviews the sections of Meek and Hayden, Swallow, and Hay. According to Meek and Hayden's estimate the Garrison formation had a thickness of 109 feet; according to Swallow the thickness is from 124 to 153 feet, while Prosser found it to be 122 feet. Meek and Hayden give the thickness of the Wreford limestone as 40 feet; according to Swal-

* Op. cit. p. 199.
† Loc. cit. p. 201.
* Bull. Geol. Soc. Amer., vi, pp. 33, 37.
† Op. cit. p. 47 et seq.

"Flint Hills Escarpment" at Garrison, Kansas. Valley of the Big Blue river. The conspicuous limestone on the crest of the bluff is Fort Riley limestone. The limestone showing by the tree on the face of the bluff just to the left of the center of the picture is the Wreford limestone.

low it is 36 to 50 feet and Hay‡ finds it to be 25 feet thick on the Fort Riley military reservation. The Matfield formation is represented on the Fort Riley military reservation by 52 feet of shales and limestones.§ Meek and Hayden give it a thickness of 67 feet in the Kansas river region. Hay assigns a thickness of 25 to 30 feet to the Florence flint, number 9 of his section, and 52 to 62 feet to the Fort Riley limestone, while Meek and Hayden estimated the thickness of the Florence flint at 38 feet.

It is probable that Mr. Hill's footnote referring to number 14 of Hay's section to the Marion formation (now called the Winfield limestone) is correct. At the time of our visit the high hill where Hay probably obtained the uppermost members of his section was the target for daily artillery practice and the writers scrupulously refrained from the study of its rocks and fossils.

On account of the condition of the exposure at the time of our visit and its accessibility a section of the rocks at Junction City is given below. The Wreford limestone in this section is hidden, occupying a terrace just above the mill. The section is located on the south side of the Smoky Hill river a little south of east of Junction City, beginning at the water level at the mill by the wagon bridge and following the wagon road to the top of the hill. This section is diagonal to the east end of Hay's section* and crosses it in a southeasterly direction.

SECTION AT THE MILL BY THE BRIDGE OVER THE SMOKY HILL RIVER A LITTLE SOUTH OF EAST OF JUNCTION CITY.

38.	Covered to the place where the road crosses the hill, limestone exposures on higher ground on either side of road	15	ft.	0	inches
37.	Limestone, shaly	15	"	0	"
36.	Limestone, buffish brown with small pelecypods	2+	"	0	"
35.	Limestone, shaly, 11 to	12	"	0	"
34.	Limestone, light colored	1	"	0	"
33.	Limestone, Fort Riley "main ledge"	5	"	0	"
32.	Limestone, rough, with "car-links" on top	3	"	6	"
31.	Shales, calcareous, yellow	9	"	0	"

‡ Bull. U. S. Geol. Surv., 137, p. 17.
§ Hay, Loc. cit. p. 17.
* Loc. cit. pl. ii.

30.	Flint and limestone, Florence flint	22	"	6	"
29.	Limestone, shaly; and shales	3	"	6	"
28.	Shales, red, green, and olive	7	"	6	"
27.	Shales, calcareous	1	"	0	"
26.	Shales, red and yellow	9	"	0	"
25.	Limestone	0	"	6	"
24.	Shales	4	"	6	"
23.	Limestone and shales	2	"	6	"
22.	Shales	2	"	0	"
21.	Shales, indurated; and limestone	1	"	6	"
20.	Shales, light colored	4	"	0	"
19.	Limestone, 0 to	0	"	4	"
18.	Shales, light reddish	4	"	6	"
17.	Limestone, slabby 6 inch to	1	"	0	"
16.	Shales, reddish	2	"	0	"
15.	Limestone, massive	1	"	0	"
14.	Covered	3	"	0	"
13.	Flint and limestone	3+	"	0	"
12.	Covered	45	"	0	"
11.	Shales, maroon and green	4	"	0	"
10.	Limestones with green shale partings	2	"	6	"
9.	Shales, green	2+	"	0	"
8.	Limestone, gray	0	"	9	"
7.	Shales, bright green	1	"	0	"
6.	Limestone	2	"	0	"
5.	Clay and shales, lower ½ cross bedded and blocky	9	"	0	"
4.	Conglomerate with calcareous cement, fish teeth, 1 inch to	0	"	2	"
3.	Clay, with smooth joints	0	"	9	"
2.	Shales, blue, green and maroon, indurated	4	"	0	"
1.	Shales, reddish, lower part covered, high water level	3	"	0	"
	Total	210	ft.	0	inches

This gives 29 feet of the Garrison formation in this exposure with probably 23 feet to be added as Hay's section gives 25 feet as the thickness of the Wreford at this locality. It is very probable that number 13 of our section is the top of the Wreford. The thickness of the Matfield formation here is 48 feet (52 feet according to Hay). The Florence flint is 22½ feet (given as 25 to 30 feet by Hay). If number 29 were added to the Florence flint it would cor-

respond to Hay's section, but would reduce the thickness of the Matfield formation an equal amount. Numbers 31 to 37 of our section are Fort Riley limestone and show a thickness of at least 47½ feet of it exposed, with the probability that much of Number 38 should be added.

The region from Junction City to Cottonwood Falls has been well summarized by Prosser.* Taking the region as a whole he ascribes a thickness of 6 feet to the Cottonwood limestone, 140 to 145 feet to the Garrison formation, 40 feet to the Wreford limestone, 60 to 70 feet to the Matfield formation, 20 feet to the Florence flint, 40 feet to the Fort Riley limestone, 60 feet to the Doyle shales and 20 to 25 feet to the Winfield limestone. Detailed sections are given in the folio referred to.

Southern Province.—South of the region represented in the Cottonwood Falls folio changes are to be noted in the appearance of some of the strata under consideration. South of the latitude of Bazaar, Chase Co., the Cottonwood limestone has never been definitely located nor its horizon accurately mapped. Keyes† states, referring to the Cottonwood limestone, that "its geographic range is wide, extending from Nebraska through central Kansas into Oklahoma." Again‡ "The stratum (Cottonwood limestone) has been traced from southeastern Nebraska where it passes beneath the Cretaceous, entirely across Kansas into Oklahoma. It often forms a noticeable topographic feature." The Cottonwood limestone has never been traced across Kansas into Oklahoma unless it was done by Keyes himself. Indeed, as will be shown in the following discussion, it can not be recognized with certainty by any of its characters south of the region just mentioned. Other stratigraphic changes occur in the Garrison, Elmdale and intermediate formations so that the members can not be recognized readily by their lithologic characters and can only be determined by carefully tracing the outcrops south from the known localities. One of the writers endeavored to locate the Cottonwood limestone in the southwest corner of Lyon county and traversed its general horizon to Reece but was unable to locate

* Jour. Geol., III, p. 773 and some of the preceeding pages. See also Cottonwood Falls Folio, U. S. Geol. Surv. Atlas, number 109.
† Amer. Geol, xxiii, 1899, p. 308.
‡ Loc. cit. p. 311.

it with certainty. At Reece, Beaumont and Grand Summit excellent exposures of all the important limestones of the entire section are shown, but nowhere is a stone with all the characters of the Cottonwood limestone to be found. The fauna of the general horizon is somewhat similar to that of the Florena shales but it is distributed through a fairly wide range of rocks and is nowhere so pronounced as in the northern localities. In short the Cottonwood limestone ceases to be of great value as a horizon marker south of the latitude of Bazaar.

The stratigraphy of this region can best be compared with that farther north by detailed sections. The regions near Reece, Beaumont and Grand Summit furnish excellent exposures of the rocks concerned in the Flint Hills escarpment. North of this region the flints have been so constantly associated with this escarpment that it has led to some errors of observation in its southern prolongation. For this reason the sections near the places just named are given in considerable detail.

SECTION FROM REECE TO SUMMIT SIDING.

70.	Limestone, massive with many chert concretions in layers	15±	ft.	0	inches
69.	Limestone, very cherty, covered with fallen chert	3	"	0	"
68.	Limestone containing 3 or 4 layers of flint. Fusulinas	3	"	6	"
67.	Limestone, shaly	3	"	8	"
66.	Shales, calcareous	0	"	8	"
65.	Limestone, shaly	1	"	0	"
64.	Shales, blue calcareous	2	"	4	"
63.	Limestone, shaly	2	"	0	"
62.	Shales, yellowish and greenish	7	"	0	"
61.	Covered	8	"	0	"
60.	Limestone, hard, massive	3	"	0	"
59.	Shales, fossiliferous	3	"	0	"
58.	Limestone, rotten, and fossiliferous	1	"	0	"
57.	Shales, yellowish, indurated, fossiliferous	9	"	0	"
56.	Limestone, rotten, and calcareous shales	3	"	0	"
55.	Shales, green and yellowish	8	"	6	"
54.	Shales, maroon	8	"	0	"
53.	Shales, bright green	2	"	0	"

52.	Limestone, massive, hard	1	"	9	"
51.	Limestone, shaly	2	"	6	"
50.	Limestone, cherty, probably 3 feet but showing only	2	"	3+	"
49.	Shales, yellow	5±	"	0	"
48.	Shales with plants, fishes and ostracods	0	"	6	"
47.	Limestone, rotten	1	"	8	"
46.	Shales, yellow	2	"	0	"
45.	Limestone	1	"	6	"
44.	Limestone with flint	1	"	2	"
43.	Shaly layer	0	"	4	"
42.	Limestone, massive	5	"	0	"
41.	Limestone with heavy flint layers	4	"	0	"
40.	Shales, yellowish and clayey limestones with fossils	7	"	0	"
39.	Shales, green	4	"	0	"
38.	Shales, maroon	12±	"	0	"
37.	Limestone, slabby	0	"	6	"
36.	Shales, light blue	5	"	0	"
35.	Limestone, shaly	7	"	0	"
34.	Limestone, hard gray	0	"	9	"
33.	Limestone, clayey and rotten, pelecypods. Same as in cut east of the big fill	10	"	0	"
32.	Limestone, shaly and slabby	4	"	6	"
31.	Shales, greenish	3	"	6	"
30.	Limestone, hard blue	0	"	9	"
29.	Shales, light greenish or bluish	8	"	0	"
28.	Clay, soft yellowish, with rotten limestone on top	2	"	6	"
27.	Limestone, shaly and slabby with some shales	10	"	0	"
26.	Limestone	0	"	6	"
25.	Shale	0	"	6	"
24.	Limestone, hard	1	"	0	"
23.	Covered, with two well-marked limestone horizons	70±	"	0	"
22.	Covered, mostly, down to top of Wooster's section; thin limestones and shales	125±	"	0	"
21.	Limestone in four layers, buff, Fusulina	3	"	0	"
20.	Shales, buff	5	"	0	"
19.	Shales, carbonaceous	2	"	0	"
18.	Limestone, buff shaly, with fossils. Fusulina	1	"	6	"
17.	Shale, blue and full of fossils. Fusulina	3	"	4	"
16.	Limestone, buff and cherty containing Fusulina	1	"	9	"
15.	Shades, calcareous	0	"	9	"
14.	Limestone, buff, Fusulina	1	"	0	"
13.	Shales, dark, buff on weathered surface. No fossils	3	"	0	"

12.	Limestone, buff, top full of Fusulina	2	"	0	"
11.	Shale	5±	"	0	"
10.	Limestone	2±	"	0	"
9.	Covered	30	"	0	"
8.	Limestone weathering to a dirty dark gray	1±	"	0	"
7.	Covered	11	"	0	"
6.	Shale, yellow, green and red with rotten limestone near the middle, thin sandstone of 1 inch or 2 inches near top	35	"	0	"
5.	Limestone in thin layers made up of pelecypods	1—	"	0	"
4.	Shales, soft clayey, and weathered slope	33	"	0	"
3.	Limestone, massive brownish, forming fall in creek	1	"	3	"
2.	Shales, green and blue soft clayey	5	"	0	"
1.	Limestone, brown, massive with Productus cora	1	"	6	"
	Total	530	ft.±		inches

Numbers 1 to 3 are in the creek west of the road just northwest of Reece, the remaining lower part of the section (numbers 4 to 9) extends up the bluff from the creek. Numbers 10 to 21 are in the cuts near the spring about 1¾ miles west of Reece on the railroad. This part of the section corresponds to Wooster's section.* Numbers 22 and 23 extend from the top of these cuts to the big fill about 7 miles N. W. of Reece. Numbers 24 to 40 are shown in the cut and stripping by the big fill (which is the same as the big trestle mentioned by Prosser); 40 to 49 are in the fourth cut east of Summit siding; 50 to 56 are in the third cut east of Summit, 57 to 60 in the second and 61 to 70 are in the first cut east of Summit.

Just prior to our visit, the great trestle on the eastern face of the escarpment had been filled, as had the smaller ones between it and the crest of the ridge. In securing the material for the fills, the available soil and loose material had been removed from the right of way in the vicinity of the cuts, leaving ideal exposures from which to make exact sections. These exposures threw light on points which were before obscure. In the light of our sections we make the following summary of formations.

Numbers 1 to 40 are Coal Measures or Pennsylvanian;

* Kans. Univ. Quart., vi, p. 153, footnote.

not being able to recognize the formations with certainty in this lower part of the section it is deemed best not to attempt to draw approximate lines to the formations, though these numbers include the equivalents of the Elmdale, Neva, Eskridge, Cottonwood and Garrison formations and probably some of the formations below. Numbers 41 to 52 are the Wreford limestone, with a thickness of over 27 feet 8 inches. The Matfield formation is represented by at least 58 feet 6 inches of rock, without number 67, which would make it 62 feet 2 inches, (numbers 53 to 67). There is more or less of a question as to whether or not number 67 should be classed with the Matfield. We are inclined to include it with the Florence flint. Numbers 67, or 68, to 70 represent the Florence flint with a thickness of 21 feet 6 inches without number 67 or 25 feet 2 inches with it.

A large amount of plant remains was taken from a cut in the wagon road just east of a small ravine near the top of the escarpment west of Reece. This horizon seemed to be the equivalent of numbers 19 and 20, though this was not determined with certainty. It is probably well down in the Elmdale formation, possibly at its base. Number 48 produced a large number of plant remains, fish and ostracods. The Cottonwood limestone was not located with certainty and as a consequence the thickness of the Garrison formation can not be stated. It seems probable that Prosser's location of the horizon of the Cottonwood limestone is approximately correct. He locates it as probably being in number 7 or 6 of his section, which is near the top of number 22 of our section. Prosser refers numbers 13-15 of his section to the Wreford limestone,* giving it a thickness of 50 feet. In looking over his notes previous to writing this paper it was discovered that in passing over the section twice his barometer gave different readings for the covered portion of the section between the two flints and in compiling the section the smaller reading was used. This was also in accordance with the general appearance of the section. Even with the sides stripped as they were at the time of our visit it was very difficult to realize the thickness of the strata exposed between the upper cuts by

* Kans. Univ. Quart, vi, p. 152. Strong flint = Wreford limestone.

walking along the railroad. The upper part of the Wreford limestone was partially concealed as was most of the Matfield formation.† Number 13 of Prosser's section corresponds to numbers 41 to 45 of our section. Number 14 of his section corresponds to numbers 46 to 47 of our section, including the shales and upper limestones of the Wreford limestone and all of the Matfield formation. The remainder of our section, numbers 68 to 70, corresponds with number 15 of his section, and represents the exposed thickness, of the Florence flint.

From the foregoing it is clear that the Florence flint forms the crest of the "Flint Hills" west of Reece. From there west to El Dorado the railroad passes down the dip-slope of this stream. Proceeding south from Reece, changes begin to appear in the rocks making up the front of the escarpment. The Florence flint falls back to the west forming another small escarpment west of the town of Beaumont and the Wreford limestone has been removed from the notch through which the railroad passes in crossing the ridge, though it appears on the crest just north and south of Beaumont. The Wreford limestone outcrops in the streets of Beaumont, somewhat below the crest of the ridge east of the town which is formed by rocks of lower horizon.*

South of the Reece section the "Frisco" railroad climbs the escarpment with numerous cuttings which produce practically a continuous exposure. No attempt was made to go to the base of the escarpment to establish a section but a base was chosen about 200 feet below the Wreford limestone, possibly in the top of the Elmdale formation. The detailed section follows:

SECTION OF THE "FLINT HILLS" ESCARPMENT EAST OF BEAUMONT.

42.	Covered, to the base of the Wreford limestone in the crest of the hill south of the railroad	20 ft.	0	inches
41.	Shales, red and blue, disintegrated, showing in cut	8+ "	0	"
40.	Shale, indurated, blue calcareous	5 "	0	"
39.	Shale, calcareous disintegrated	3 "	6	"

† This correction also applies to the section published in U. S. Geol. Surv. Folio 109, p. 3, column 3.
* Sellards left the field at the close of the work at Reece.

38.	Limestone, massive, fine chert concretions in top	1	"	3	"
37.	Limestone, shaly, and calcareous shales, upper part, very fossiliferous	5	"	9	"
36.	Limestone, impure, some chert	2	"	0	"
35.	Shales, gray, and thin sheets of limestone	1	"	6	"
34.	Limestone, hard bluish, weathering buffish, layer of pelecypods on top	2	"	0	"
33.	Shales, olive, clayey	5	"	0	"
32.	Crusty deposit	1	"	0	"
31.	Shales, blue	2	"	0	"
30.	Shales, calcareous concretionary	2	"	0	"
29.	Shales, yellowish calcareous	3	"	0	"
28.	Limestone, blue, hard and slaty with some fossils	6	"	0	"
27,	Limestone, massive with occasional chert concretions, shaly above and cherty below. *Pseudomonotis*	5	"	6	"
26.	Shale, blue, hard, disintegrated, some fossils	3	"	0	"
25.	Covered to the base of the previous cut	10	"	0	"
24.	Shales	1	"	6	"
23.	Limestone, rotten	1	"	0	"
22.	Shales, light colored	12	"	6	"
21.	Limestone, rotten	1	"	0	"
20.	Shale	2	"	0	"
19.	Limestone	1±	"	0	"
18.	Covered to limestone 5 feet below previous cut	5	"	0	"
17.	Shales, yellow calcareous, some fossils	12	"	0	"
16.	Covered	15	"	0	"
15.	Shales, crusty	2	"	0	"
14.	Limestone, shaly above and massive below	8	"	0	"
13.	Shales, light colored, clayey, to base of last cut	10	"	0	"
12.	Limestone, massive, in three layers, *Fusulina* on top	6	"	0	"
11.	Shales, calcareous, with some fossils	3	"	0	"
10.	Shales, yellowish, to base of previous cut	12	"	0	"
9.	Limestone, shaly	1	"	0	"
8.	Shales, light colored, clayey	5	"	0	"
7.	Covered	5	"	0	"
6.	Limestones, two thin ones, with shaly parting	1	"	5	"
5.	Shales, blue, calcareous	5	"	0	"
4.	Limestone, massive, flesh-colored, gastropods, pelecypods and cephalopods	2	"	6	"
3.	Limestone, yellowish and impure, and shales fossils	5	"	0	"
2.	Shale, blue, some fossils	2	"	0	"

1. Limestone, gray, rotten	1	" 0	"
Total	206	ft. 3	inches

Numbers 1 to 10 are in the fifth cut on the big curve going east. Numbers 11 to 13 are in the fourth cut, 14 to 16 in the third, 17 to 19 in the second and 20 to 25 are in the first cut on the big curve going east. Numbers 26 to 33 are in the cut a half mile east of Beaumont junction and numbers 34 to 40 are in the first cut east of Beaumont. In other words the section beginning at number 40 and passing eastward down the escarpment along the railroad is exposed in the first seven cuts.

It seems probable that number 12 of this section is in the approximate horizon of the Cottonwood limestone, judging from its general appearance and position in the section, and number 13 carries a fauna similar to the Florena shales and has a resemblance to them. If this suggestion should prove to be correct the thickness of the Garrison formation at this locality would be 146 feet.

The two streams heading on the crest of the ridge have removed the Wreford limestone from the point where the railroad crosses the ridge as stated above, but appears on the ridge just south of the railroad.

Eighteen miles south of Beaumont is the Grand Summit region famous for its fossils. The logical approach to this region is from the north where the Beaumont section furnishes a valuable key to the conditions here.

This section will be considered in two parts, the Grand Summit, or lower, section and the Cambridge-Burden, or upper, section. The detailed section of the Grand Summit half follows:

GRAND SUMMIT SECTION.

29.	Shales, blue, with calcareous sheets and millions of fossils	15	ft. 0	inches
28.	Limestone, blue, clayey	1	" 0	"
27.	Shales, blue, yellow above	5	" 0	"
26.	Shales and shaly limestone	5	" 0	"
25.	Limestone, somewhat massive, weathering light	8+	" 0	"
24.	Shales, calcareous, and impure limestone.....	7	" 0	"
23.	Shales, clayey, with calcareous layer, very fos-			

	siliferous	7+	" 0	"
22.	Limestone, clayey, nodular and clay shales. Some fossils	3	" 0	"
21.	Shales, yellow and blue with calcareous lenses. Sea urchins	5	" 0	"
20.	Covered, 5 feet to	8	" 0	"
19.	Shales, red	5	" 0	"
18.	Shales, blue	1	" 0	"
17.	Limestone, blue, massive	1	" 0	"
16.	Shales, yellow and red, 1 foot of limestone near the base	10	" 0	"
15.	Limestone, massive in one layer	3	" 0	"
14.	Shales, yellowish, calcareous	1	" 4	"
13.	Limestone, shaly	1	" 0	"
12.	Shales	0	" 4	"
11.	Limestones, two thin ones	0	" 4	"
10.	Shales	0	" 6	"
9.	Limestone, buff to brownish large *Fusulinas* and chert in the lower part	6	" 0	"
8.	Shales, clayey	1	" 9	"
7.	Limestone, shaly to massive	3	" 9	"
6.	Shales, yellowish	3	" 3	"
5.	Limestones, thin, with shale partings	3	" 0	"
4.	Limestone, massive, in two layers	3	" 4	"
3.	Shales, yellowish, with calcareous layers rich in fossils	9	" 0	"
2.	Limestone, dark colored, in thin layers full of pelecypods	4	" 0	"
1.	Shales, red and blue, in creek north of the cut, east of the trestle over the small creek	11	" 0	"
	Total	132	ft. 7	inches

There are somewhere from 90 to 125 feet of rocks in the hills to the north of Grand Summit which should be added to this section, but they are better exposed in the section which is to follow. The Wreford limestone caps the top of the hills north of Grand Summit and is in the big ridge west of town. The most conspicuous feature of the Wreford limestone here is the great blocks of semisilicified limestone, apparently formed by infiltration. This is a character of this limestone throughout its southern extent but more pronounced here than farther north. These blocks weather out brown and the farmers use them to fill mud-holes in the road, build fences, &c., calling them "sandstones."

They are very porous and light and have the smooth joint surfaces of chert. The top of the hill west of Grand Summit registered 90 feet above the town. Taking the dip into consideration this would add more than 90 feet to the Grand Summit section. The dip to the west is probably equal to the railroad grade.

The limestone quarried at Cambridge may be number 25 of our Grand Summit section, but it seems probable that it is one a little higher in the series. At Grand Summit there are four layers of limestone with intervening shale beds of considerable thickness, between the top of our section and the base of the Wreford limestone. The limestone quarried west of town at Cambridge is 94 feet below the base of the Wreford limestone. The latter is excellently exposed across the creek south of the quarry, where a fairly good section of the underlying rocks is to be had, on the point just east of the mouth of the little tributary from the south. The following section is a compilation of this exposure with those from the old Torrence station, just west of Cambridge, along the railroad to Burden. From Torrence (old station at the Creek) to Burden at the top of the escarpment almost all the strata are excellently exposed.

THE SECTION FROM CAMBRIDGE TO BURDEN.

39.	Chert concretions and weathered limestone, top of Burden cut	2+	ft.	0	inches
38.	Limestone, massive, with chert in layers	10	"	0	"
37.	Limestone with numerous chert concretions	10	"	0	"
36.	Shaly calcareous layer with some fossils	3	"	6	"
35.	Limestone, shaly, full of pelecypods	2	"	0	"
34.	Shales, dark red and blue	6	"	6	"
33.	Shales, bluish	3	"	0	"
32.	Bluish marl	1	"	0	"
31.	Shale, red	4	"	0	"
30.	Limestone, shaly below	2	"	0	"
29.	Covered	20	"	0	"
28.	Shale, bluish, and calcareous nodules	0	"	6	"
27.	Massive limestone, two layers	5	"	6	"
26.	Limestone, impure, shaly; shales on top	2	"	0	"
25.	Shales, blue and olive	9	"	0	"

24.	Limestone, massive, mottled and rough	3	"	0	"
23.	Limestone with three thick layers of chert	3	"	0	"
22.	Covered	8	"	0	"
21.	Olive shales	2+	"	0	"
20.	Shale, yellow, arenaceous	1	"	0	"
19.	Limestone, massive, chert in top	1	"	6	"
18.	Limestone with large chert concretions	6	"	0	"
17.	Limestone, partially silicified and carrying chert	1	"	6	"
16.	Limestone with coarse chert concretions	4	"	6	"
15.	Limestone full of small chert concretions	5	"	0	"
14.	Shales, calcareous and impure limestones, *Derbyas*	8	"	6	"
13.	Clay shales	9+	"	0	"
12.	Shales, red	5+	"	0	"
11.	Covered	15	"	0	"
10.	Limestone, rough, massive	3	"	6	"
9.	Shales	8	"	6	"
8.	Limestone, fossiliferous	1	"	0	"
7.	Covered	5	"	0	"
6.	Limestone, springy slope beneath, (S. of Cambridge quarry)	2±	"	0	"
5.	Covered	34	"	0	"
4.	Shales, blue, slaty, calcareous, in quarry	4	"	0	"
3.	Limestone, hard, massive, fossiliferous	0	"	9	"
2.	Limestone, massive, hard	2	"	6	"
1.	Covered to creek bed	41	"	0	"
	Total	254	ft.	3	inches

Numbers 2 and 3 are exposed in the quarry west of Cambridge. Lithologically the stone of this quarry is strikingly like numbers 27 and 28 of the Beaumont section, which would be somewhat above number 25 of the Grand Summit section. However Prosser is of the opinion that the rock in the Cambridge quarry is identical with number 25 of the Grand Summit section.* On the whole the Grand Summit section and the Cambridge to Burden section are to be considered as continuous. Whether or not numbers 2 and 3 of the Cambridge section are the same as number 25 of the Grand Summit section is a matter of minor importance to the consideration of the sections as a whole. Numbers 15 to 24 represent the Wreford limestone with a thickness of

* Kans. Univ Quart., vi, p. 166. This limestone he correlated with the Wreford limestone (= Strong flint).

35 feet 6 inches. Numbers 25 to 36 represent the Matfield formation with a thickness of 59 feet, while numbers 37 to 39 are the Florence flint, 22 feet of which is exposed.

Adams ran a generalized section over this same railroad from Grenola to Grand Summit and Burden. However the only section he gives is that of plate ix which appears to be entirely generalized.† He correctly states that Burden is higher geologically than Grand Summit. However he represents the dip to the west as being much less than the slope while in fact it is about as steep as the railroad grade. In other words he represents almost all of the Burden section as being a repetition of the Grand Summit section while as a matter of fact none of the rocks are repeated. He also shows the same layer of limestone appearing in the escarpment east of Grand Summit, at Grouse creek, Little Cedar creek and the Walnut river at Winfield, while the writer finds the rocks occurring in the latter place (Fort Riley limestone are stratigraphically above those at the top of the grade at Burden. It is possible, however, that his whole section is but a generalization and the plate merely illustrates that the rocks dip to the west in a general way with no attempt to represent it accurately, or show the relation of the strata.

According to Adams the dip is 10 feet to the mile to the west. Cambridge is five miles west and four miles south of Grand Summit, and the difference of elevation between the two places is 193 feet,* but the difference in altitude between number 27 of Prosser's section and the quarry at Cambridge is given as 145 feet making the dip, as given by Prosser, 16 feet per mile to the south west. However, the dip is probably more to west than to the southwest, so that it would be greater in a westerly direction than is shown between Grand Summit and Cambridge.

The first account of the Grand Summit section was published by Broadhead in 1883 or 1884.† This paper was a generalized one and is amply discussed by Prosser.‡ Broad-

† A section from Galena to Wellington. By G. I. Adams,, Univ. Geol. Surv. Kans., I, p. 27, pls. i, ix, 1896.

* Bull. U. S. Geol. Surv., 160, pp. 225, 229, 1899. The elevations given are 1438 and 1245 feet, respectfully.

† Trans St. Louis Acad. Sci., iv, pp. 486, 487.

‡ Op. cit. pp. 160-168.

head considered number 11 of his section as Permian. This corresponds to number 5 of Prosser's section and is considerably below the base of our section. At the time Prosser's paper was written the Cottonwood limestone was considered the base of the Permian. He correlated number 17 of his section, provisionally, as the Cottonwood limestone and number 18 as the base of the Permian. This is still below the base of our section.

Unless one has seen the section at Beaumont or the one from Torrence to Burden it would be difficult to get the proper understanding of the Grand Summit section. Broadhead, Adams and Prosser ran sections over the Grand Summit ridge, but Adams alone studied the section from Cambridge to Burden, and should have given it the proper interpretation. They considered the ridge on which Grand Summit is located as the "Flint Hills" escarpment and its rocks the equivalent of those found occupying a similar position farther north. Several facts contributed to this error. In the first place the limestones of the Garrison formation have become more conspicuous and misleading in this region and, secondly, the opposition of the heads of rather large streams on either side of the escarpment has tended to increase the hight of its eastern face and at the same time has removed the upper strata completely. At Grand Summit the thick limestone, by the upper cut, weathers strikingly like the less cherty portions of the Wreford limestone. This limestone is represented in number 28 of Prosser's section near the top of number 1 of Broadhead, and is number 25 of our section. Number 28 of Prosser, the fossiliferous layer, was supposed to be the fossiliferous horizon in the middle of the Wreford limestone, as at Council Grove and some other localities. Number 28 of Prosser's section is equivalent to number 29 of ours. Numbers 27 and 20 of his are the same as numbers 25 and 1 of ours, respectively.

From what has preceded it will be clear that the heavy limestone by the last cut at Grand Summit is not the Wreford limestone but is stratigraphically at least 90 feet below it, as are the quarries at Cambridge. This change in the interpretation of the stratigraphy is very important to the paleon-

tologist as it places the great fossil horizon at Grand Summit in the Garrison formation instead of in the Permian.

The horizon of the Cottonwood limestone can not be located with certainty, but it may be near number 9 of our section.

The appearance of the exposure of the lower Wreford limestone in the cut east of Dexter, Cowley county, is typical of its southern extension, showing well the imperfectly silicified limestone, "sandstones" of the inhabitants, and heavy chert layers. In this region local structure becomes a factor in studying the stratigraphy of these rocks. The writer hopes to be able to complete the study of the stratigraphy of his county the coming season. In the mean time, however, it is well to correct the section of the bluffs north of Arkansas City, measured by Beede in the summer of 1896. This section was measured in the evening at a bad exposure and further study of better exposures gives the following section. The first section was published by Prosser.*

SECTION OF BLUFF NORTH OF ARKANSAS CITY.

12.	Limestone, fossilliferous, porous	10	ft.	0	inches
11.	Shales, yellow calcareous	2	"	6	"
10.	Limestone, rotten clayey	3	"	0	"
9.	Yellow shales	2	"	0	"
8.	Covered	2	"	0	"
7.	Limestone	1	"	8	"
6.	Shale, yellow	5	"	0	"
5.	Shale, blue and green	15	"	0	"
4.	Limestone	0	"	4	"
3.	Covered	7	"	0	"
2.	Limestone	1±	"	0	"
1.	Covered to level of bottom land	10	"	0	"
	Total	59	ft.	0	inches

Prosser† was inclined to refer this section to the Marion formation and the exposure on the opposite side of the Walnut river, east of the Santa Fe depot, to the Winfield formation. However, in the light of the better section and the concretions on the ground, on the bluffs north of the city, it seems seems probable that number 6 of this section is the

* Op. cit. p. 174.
† Op. cit. p. 174.

Winfield limestone and that the remainder should be assigned to the Doyle shales while the limestone east of the Walnut probably represents the Fort Riley limestone. However this is merely a guess and the stratigraphy will have to be worked out before the matter can be settled definitely.

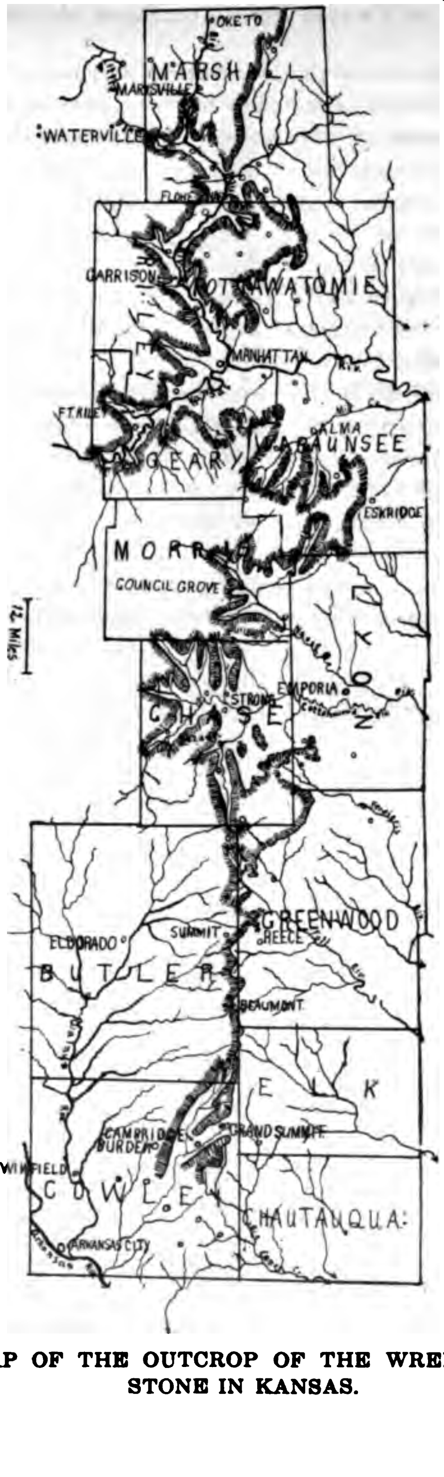
CONCLUSION.

From what has preceded it will be seen that the strata of the lower Permian are remarkably persistent and uniform when the great extent of the outcrop is considered. The Cottonwood limestone, though only about six feet thick persists with every detail of structure and fauna over one-hundred miles of strike and several times as great an outcrop, though it has not been identified with certainty in the southern part of the state. The Garrison formation extends entirely across the state with but slight modifications in the southern part, such as the thickening of some of its limestones and the possible interpolation of others. The Wreford limestone is remarkably uniform throughout the entire distance from Nebraska to the southern line of Kansas, being most highly developed in the central part of its outcrop in the region of Cottonwood Falls. In the Matfield shales about the only change worthy of special notice is the thickening of a layer of limestone and the coming in of an additional one in the southern part of its outcrop. There are no striking changes in the Florence flint aside from a slight fluctuation in its thickness, being somewhat thicker in the central and southern regions.

Three maps have been published which show either in part, or in a general way the whole outcrop of the Wreford limestone and associated strata in Kansas. The first was published by Beede* and shows the outcrop, in a general way of the Cottonwood formation, Neosho, Chase and Marion stages in the region north of the Kansas river. The line between the Neosho and Chase stages is the line of outcrop of the Wreford limestone.

The second was published by George I. Adams in an article entitled "Physiographic divisions of Kansas† and shows in a very general way the location of the "Flint Hills

* Kans. Univ. Quart., ix, pl. xliii, 1900.



THE MAP OF THE OUTCROP OF THE WREFORD LIMESTONE IN KANSAS.

Escarpment" in Kansas. The map of Kansas is a little less than three inches by six in his article. The location of the escarpment north of the Kansas river was taken from Beede's map.

The third of these maps is to be found in the Cottonwood Falls folio of the U. S. Geological Survey.‡ This map shows the details of the stratigraphy of the rocks within its area discussed in this article, and to it the reader is referred for an idea of the intricate nature of much of the outcrop of the Wreford limestone.

The data of the first and last maps mentioned were used freely in constructing the accompanying map, on which is shown the outcrop of the Wreford limestone. The line between Eskridge and Junction City is hypothetical a part of the way, as it is locally, though always in very much shorter distances, in a few other places. The width of the stream-etched portions of the escarpment is purposely enlarged for the sake of clearness. Southern Cowley county has not yet been mapped.

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† Trans. Kans. Acad. Sci., xviii, 1903.
‡ Cottonwood Falls Folio, U. S. Geol. Surv. Atlas, number 109, Prosser and Beede, 1904.

THE FUNDAMENTAL COMPLEX BEYOND THE SOUTHERN END OF THE ROCKY MOUNTAINS.

By Charles R. Keyes, Socorro, New. Mex.

Soon after passing the southern boundary of Colorado the Rocky mountains rapidly dwindle and disappear as a pitching anticline beneath the plains of the Mexican tableland. In this limited New Mexican area the Archæan, or Azoic, rocks form the cores of several of the principal ranges. The last exposure of the fundamental complex is in the Apache canyon, which the Atchison, Topeka and Santa Fe railway makes use of in crossing the mountains. South of this locality the only exposures of ancient crystallines are in the great fault-scarps of the block mountains, which rise out of the plains, forming the general surface of the Mexican tableland and the New Mexican portion of the High Plateau region.

During recent years many facts have been brought to light which have very radically modified opinion regarding the great crystalline basement underlying all the Paleozoic sequence in New Mexico. Most of the extensive formations composed of granites, schists, and gneisses which form the axial foundations of so many of the mountain ranges of the region are now believed to be of much later geological age than is generally understood to be covered by the title, Azoic or Archæan.

In summing up our knowledge on the subject, a decade ago, in his paper, the Pre-Cambrian Rocks of North America, Van Hise* remarked:

"It is evident from the literature that in western New Mexico and in the major part of Arizona is a fundamental, thoroughly crystalline complex, consisting of most intricately mingled and folded granites, gneisses, micaceous and hornblendic schists, etc., precisely as in the previous sections concerned with the Rocky mountain system. This complex occurs at many points, constitutes the axes of many ranges, and its structure is of so intricate a character that no attempt has been made to estimate its thickness or to work out its structure, although in general the laminated rocks have been referred to as metamorphic. The granite in this complex plays the same part with reference to the crystalline schists as in the other areas referred to. Besides this ancient granite, which existed before the next newer series of rocks was formed, there is apparently

* Bull. U. S. Geol. Surv., No. 86, p. 331, 1892.

in certain areas granites of later age, and these are more plentiful as the western part of Arizona is reached."

In the light of the recent discoveries that in some of the mountain ranges of New Mexico portions at least of the crystalline foundation are of clastic origin, it becomes necessary to devise criteria by which the crystallines of the fundamental complex (Archæan) may be separated from those that have a sedimentary origin. Until the application of these criteria to every mountain range is made, no general deductions can be drawn concerning the exact ages of the different crystalline formations. The reasons for this statement are obvious from even a casual examination of the basal crystallines in New Mexico. It is known that in all of the New Mexican mountains where the crystalline basement is open to view a marked unconformity exists at the base of the fossiliferous sequence. The late Carboniferous limestones generally rest directly upon the granites, gneisses and schists, the foliation of which is more or less steeply inclined or even vertical.

That the erosion interval represented by the unconformity was very long is quite evident. In southern New Mexico the early Carboniferous limestones begin to make their appearance. Then come Devonian beds, Silurian or Ordovician, and finally what appear to be Cambrian. A horizon of great unconformity persists under all the Paleozoics.

Something of real significance of the old erosion plain becomes manifest by reference to the geological section displayed in the Grand Canyon of northwestern Arizona towards the western border of the High Plateau region. The author* just quoted describes the following general conditions:

"The Tonto sandstone of the Grand Canyon region, called by Powell and Gilbert Silurian in accordance with the nomenclature of the time, by present classification is to be placed as Upper Cambrian. The great unconformity which separates this sandstone from the earlier series makes it very probable that the latter are pre-Cambrian. These inferior series in descending order are the Chuar, Grand Canyon, Vishnu series (together the equivalents of Powell's

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* Loc. cit., p. 331.

Grand canyon group), and the basal complex. The upper series consists of shales and limestones. Below this, with an erosion interval, is the second, consisting of sandstones, with interbedded and cutting basic eruptives. Inferior to this series, and separated by a great unconformity, is a set of thinly bedded and nearly vertical quartzites of undetermined thickness, broken by intrusive masses of granite. These three are clearly clastic series. The basal complex as described by Powell and Gilbert consists of thoroughly crystalline hornblendic and micaceous schists, gneisses, and granites, like the fundamental complex of the remainder of New Mexico and Arizona. Between this basal complex and the Vishnu series, as shown by Powell, is a vast unconformity. We have then in this region passing from the base upward, a fundamental complex; great unconformity; quartzite series of unknown thickness (Vishnu); great unconformity; Grand Canyon series; minor unconformity; Chuar series; great unconformity; Cambrian."

There are then recognizable in the Grand Canyon part of the region at least four great unconformities in the space between the undoubted fundamental complex of Archæan age and the Cambrian sandstones. Each of these four unconformities represents a long period of time when the rocks were elevated above the sea, flexed and then subjected to enormous denudation. Powell† has estimated that in the case of the latest of the intervals mentioned which is represented at the base of the Cambrian sandstones, at least 10,000 feet of beds were bowed up, contorted and eroded in such a manner as to leave but fragments in the synclinals.

Each of the great unconformities represents similar conditions. In New Mexico these four periods of enormous erosion were probably superimposed. The clastics of the Proterozoic must have suffered tremendously. Over very large areas every vestige must have been removed. In all likelihood only scattered remnants remained. Thus in adjoining mountain ranges the crystalline basement may be of Archæan age in the one case, while in the other it may be Proterozoic.

The differentiation of the fundamental Azoic complex from the Proterozoic crystallines must rest upon the application of some such scheme of critical criteria as has been so successfully formulated in the Lake Superior region.

While there is as yet much uncertainty regarding the

† U. S. Geog. and Geol. Sur. Terr. 1876.

position and geological age of the basal crystallines in many of the different mountain ranges there are some instances in which there exists but small doubt as to their Azoic position. The general proofs are in a measure comparative. They are the relative amount of metamorphism evidenced, the character of the deformation apparent, the difference in petrographical features, the geological relationships, the absence of all evidences of clastic origin, and a comparison with similar features of known areas in other parts of the country.

The literature relating to New Mexican Azoic formations refers all the basal crystallines to the Archæan. Little of definite value therefore can be gleaned grom the widely scattered published descriptions of local phenomena. The first suggestion that any portion of the ancient crystallines occurring within the boundaries of New Mexico were any other than of Archæan age is believed to be a recent statement regarding the significance of the recent identification of certain "quartz-reefs" in the Sandia mountains as highly metamorphosed sandstones.*

The present surface exposure of the great crystalline basement underlying all the fossilferous strata in New Mexico is relatively small. Aside from the area in the southern Rocky mountains in the northern part of New Mexico the exposures of pre-Cambrian rocks are confined almost to linear outcrops found along the immense fault-scarps of the block mountains. Some of these outcropping faces indicate that the rocks are of undoubted Azoic or Archæan age, while others are manifestly of clastic nature and thus belong to the Proterozoic.

In order to understand more fully this apparent anomalous distribution it is necessary to refer to some of the general conditions prevailing in neighboring states that the geological history discloses. The conception is that the upper surface of the ancient crystalline basement in this region represents an old peneplane on which, when submergence took place in Proterozoic times, an enormous thickness of sedimentaries was laid down. This whole country, still in pre-Cambrian times, was folded up into mountain

* Eng. and Mining Jour. vol. lxxvi, p. 967, 1903.

ranges, not once, but repeatedly. Finally before the Cambrian strata of the region were deposited the entire country, already profoundly folded, faulted and cut frequently by intrusives was planed down to a prodigious extent. On this new peneplane only isolated patches of the clastic rocks of Proterozoic age survived—only those portions caught in the lowest parts of complex troughs, the bottom of synclinoria. These remnants of the Proterozoic sedimentaries now appear so intensely metomorphosed that they have until quite recently entirely escaped notice. At best it is only with the greatest difficulty that the rocks of the two great ages can be differentiated.

In many of the mountain ranges the crystalline basement is composed partially or entirely of gray or red granites which show little or no evidences of shearing or subjection to great oroganic pressure. It has been customary to regard these masses as composed of Archæan granite. Now granites of this description, practically unaltered, are known to traverse or be intimately associated with the undoubted Proterozoic crystallines. On the principles involved in the separation of unfossiliferous geological formations according to the relative amount of deformation and comparative degree of metamorphism, these unaltered granitic masses are tentatively referred to the Proterozoic, though for convenience in treatment some of them probably have to be considered for the present in connection with the other rock-masses in which they occur.

At some risk, perhaps, in the present state of our knowledge, of swinging too far in the direction opposite to that heretofore generally accepted, it seems most advantageous to proceed on this hypothesis. In support of this position there are many other reasons which should be fully discussed in connection with the detailed descriptions of the Proterozoic crystallines. For the present only those crystalline rock-masses will be considered as belonging to the Archæan fundamental complex, that consist of much sheared granites, crumpled gneisses and schistose rocks not associated with undoubted clastics.

Probably the main reason for the lack of definite and discriminating information regarding the pre-Cambrian

rocks of southwestern United States has been the comparatively limited exposures. Another factor has been that the examination of the formations has been an incidental object in connection with hurried expeditions undertaken for other than geological purposes. In New Mexico the exposures of the pre-Cambrian crystalline basement are for the most part linear in character. There are in this region a score of prominent mountain ranges in which the basal crystallines are exposed to view. At least in half of this number the rocks are with but small doubt of Azoic age. Several ranges present crystallines which are of undoubted clastic origin. In the remainder the age of the crystallines is not definitely known.

Most of the ranges will have to be studied anew in the light of the more modern conceptions rendering possible the differentiation of the old crystallines into well defined geological formations. In the southern Rockies, which extend down from Colorado less than a third of the distance to the southern boundary of New Mexico, there are four large areas of basal crystallines all of which, until undoubted clastics are discovered in them, may be considered as composed of Azoic formations. As a whole the ranges which collectively go to make up the southern extremity of the Rockies are generally known as the Snowy mountains or the Sangre de Cristo ranges. As the four areas of Azoic rocks mentioned are more or less distinctly separated from one another, they will be here taken up briefly in turn.

The largest and most important area of ancient crystallines occurring in New Mexico is the one entering from the north from Colorado. Comprised within the area are the two important ranges, Culebra, and Taos, which are almost wholly made up of old crystallines. The principal rocks are hornblendic schists, biotitic schists, gneisses, gneissoid granites and coarse-grained unmodified granites. Stevenson* frequently mentions in this and neighboring districts the existence of beds of quartzite in the granitic and gneissic rocks. Whether or not all of these "beds" are really quartzitic clastics cannot now be told. From what is personally known of the character of the rocks generally in this region

* U. S. Geog. Sur. W. 100 Merid., vol. iii, Supp., p. 68, 1881.

it is not believed that any of them are of clastic origin. Some of them are certainly aplitic; and others are known to be quartz-veins inclined at low angles.

According to the writer just mentioned, the rocks immediately north of the boundary line in Colorado are predominantly hornblendic schists, though there are some mica schists present. These schists occupy the middle and highest portions of the axis. On the east side of the range gneisses and gneissoid granites prevail, together with some mica schists. A coarse-grained granite is also frequently met with.

Southward, within the limits of New Mexico, the hornblendic schists become less and less prominent. At the boundary line the Azoic belt is not more than 6 or 7 miles in width, but within a short distance it rapidly broadens out to 20 miles. The prevailing rocks are dark and light colored gneisses, some bands of the latter very closely resembling beds of quartzite. Occasionally bodies of coarse-grained granites are met with.

Bordering the front of the Rockies, from a point near the northern boundary of New Mexico and extending southward a distance of over 30 miles, is a rugged ridge known as the Cimarron range. These mountains are composed largely of Tertiary eruptives. Where the range is deeply cut by canyons which traverse it, as for example on the Rayado, the Cimarron, and several branches of the Vermejo, Azoic rocks are disclosed beneath the spread-out eruptives. These old crystallines are chiefly light colored micaceous schists and dark hued fine-grained gneisses. Occasionally these rocks are broken through by coarse-grained red granites.

In the southern part of the range the base of crystallines is covered by basalt flows from the great Ocate crater, which rises out of the plains a few miles to the southeastward.

The areal distribution and the structural relationships of the Azoic basement in the southern part of the Cimarron range are at present somewhat obscure. The apparent irregularities in the distribution of these rocks is probably due largely to the presence of the Mora arch which extends in a

northwesterly and southeasterly direction through the Turkey mountains. The genesis of this arch is probably of quite recent date. It crosses the great fault that runs along the eastern front of the Rockies which late erosion has greatly obscured at this point.

The Azoic core of the Las Vegas and Mora ranges forms a narrow belt which begins a few miles north of the crossing of the Pecos river by the Atchison, Topeka and Santa Fe railroad and extends northward a distance of 65 miles. It is bordered on each side by wide belts of Carboniferous limestone. The most prominent peak is Solitario, which rises to a hight of 10,260 feet above sea-level.

At the northern extremity, the rocks appear to be almost entirely hornblende schists. A few miles to the southward light colored micaceous schists and gneisses are the prevailing rocks, with some dark colored gneisses occupying the central portion of the belt. At Mora the principal rock is a gneissic granite, while farther on appear again the micaceous schists. From the Cebolla canyon the gneisses and schists appear to be profoundly affected by deformation agencies. From Solitario peak southward the predominant rock is a coarse-grained granite with occasional bands of gneiss.

The east side of the Rio Grande valley in northern New Mexico is bordered by the lofty Santa Fe mountain range, the highest peak of which, known as Baldy, is 12,660 feet above the sea-level. The central axis of this range is comuosed of ancient crystallines bordered on each side by Carboniferous rocks. The crystalline belt is 50 miles long, by 6 to 8 wide in the broadest place. At the southern end in the Apache canyon the prevailing rock is a red granite. Granite bands and masses appear at frequent intervals farther north in the gneisses and micaceous schists. In the Santa Fe canyon there occur in the gneiss bands of argillaceous slate. Farther north the rocks present similar geological characters.

Archæan granites are reported by Stevenson as composing the Placer (Ortiz) mountains, 20 miles south of Santa Fe. No granite is found in these mountains. The rocks are micaceous and augitic andesites of laccolithic origin,

and probably of early Tertiary age. The same is true of the neighboring Los Cerrillos hills, the Cerro Pelon, the Tuertos group, and the San Ysidro.

Thirty miles west of the Rio Grande, and about the same distance north of the city of Albuquerque are the Nacimiento and Jemez mountains. The first mentioned of these is a block mountain 20 miles long. Along the great fault scarp, and under the Carboniferous limestones forming the backslope, the basal crystallines are well exposed. These appear to be chiefly granites, so far as observation goes. Their age is as yet undetermined. They are for the present referred to the Azoic.

Near the continental divide west of Albuquerque is located the Zuni dome, its top eroded off down to the crystalline basement. The age of the pre-Carboniferous crystallines is presumably Azoic. As early as 1856 Marcou* mentions a belt of crystallines in the heart of the Zuni range 12 miles wide, consisting of reddish granite, gneiss and schist. Blake† also calls attention to the gneisses and granites of this district, and corroborates Marcou's observations. In Dutton's‡ account of the Zuni plateau the presence of gneisses or schists is not mentioned. The granites are called Archæan. If, however, the observations recorded are correctly interpreted some of the granites are certainly of much later intrusion. This author states that they have metamorphosed the overlying Carboniferous limestones, and calls particular attention to this phenomenon as it is well displayed in Mt. Sedgwick, the most prominent feature in the field.

The remarkable mountain blocks known as Sierras Oscura and San Andreas are over 100 miles long and extend northward from the Organ mountains north of El Paso. The fault-scarps of the two ridges face each other at their proximate extremities, a flat valley lying between the two. Herrick* mentions the granitic character of the crystallines beneath the the Carboniferous limestones, which dip in opposite directions in the two ranges. The age and lithologic

* Pac. R. R. Sur., vol. iii, p. 170, 1856.
† Pac. R. R. Sur., vol. iii, p. 38, 1856.
‡ U. S. Geol. Sur., 6th. Ann. Rept., p. 158, 1886.
* Bull. N. M. Univ., vol. ii, Fasicle No. 3, p. 5, 1900.

character of the crystalline basement are presumably similar to those of the Organ mountains, immediately to the south, which have in fact a genetic relationship to the San Andreas range.

While properly a continuation of the San Andreas and the Franklin mountains to the south the Organs belong to a distinct block which has been elevated much more than any other portion of the long ridge to which they belong. In consequence the sedimentary rocks have been entirely removed except at the very base on the west side.

The rocks of the Organ mountains are chiefly red and gray, coarse-grained granites. Associated with these are hornblendic and micaceous schists, which are traversed by numerous dikes, which are quartzose, dioritic and andesitic in character. Proterozoic quartzites and clay slates are well developed a few miles to the south, in Texas, and it is probable that these also extend into New Mexico. According to Walcott the thickness of the pre-Cambrian clastic section is over 3,000 feet.

In Perry's notes* on the geology of the Mexican boundary mention is made of the granites underlying the Carboniferous limestone of Franklin mountain north of El Paso and in the Organ mountains, but no specific reference is made to their age. G. B. Shumard† passed through the Organ mountains in 1857 and noted on the east side hornblende and mica schists, and red and gray granites, all of which were cut by dikes of quartz, greenstone and porphyry.

Thirty miles west of the San Andreas range the Caballos mountains rise abruptly above the Rio Grande valley. These form a block mountain in which the crystalline basement is exposed for a vertical distance of 1,500 feet. Biotitic schists, gray crumpled gneisses, and granites form the principal rocks. The granites are of two principal kinds. One, which is more closely identified with the gneisses, is gray, rather fine-grained and contains a large amount of quartz. The other is a coarse-grained, red granite, which appears to be a late intrusive, though it does not penetrate

* United States & Mexican Bound. Sur., vol. i, pl. ii, p. 8. 1857.

† Jour. Geol. Obs. Texas and New Mexico, in 1855-6, p. 113, Austin, 1886.

the overlying Carboniferous limestones. So far as has been observed there are no evidences of the existence of clastic rocks associated with these gneisses.

In the Santa Rita mountains, in Grant county, the basal crystallines underlying the Paleozoic limestones are composed chiefly of schists. The exposures are small, and little detailed information on the subject is at present available.

The great Mogollon uplift in western New Mexico appears to have an extensive foundation of ancient crystallines. The region is so covered by late eruptives that most of the former exposures are covered up. The same conditions prevail in the neighboring parts of Arizona. Reagan* appears to have found evidences of the presence of both Archæan and Proterozoic formations. The rocks of Azoic age consist of micaceous, talcose, chloritic, and hornblendic schists, and some granites.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The Two Islands, and what came of them. THOMAS CONDON. pp. 211, pls. 30. Portland, Oregon, J. K. Gill Company, 1902, $1.50.

While the author of this volume attempts to supply a popular rather than a scientific want, yet the treatment of the geology of Oregon is thoroughly scientific. The author is a well known geologist who has alone represented Oregon in geological work and geological literature for a life-time. In his declining years he has gathered together the leading facts, discovered mainly by himself, and has in this book preserved them to science, and to the credit of his own labors. He has a large collection of Oregon vertebrate fossils, and he has supplied others to eastern paleontologists. The writer has known of his vigorous activity since the days of his earliest geological work.

The two islands described are named Shoshone and Siskiyou, the former in the northeastern part of the state,, in the region of the Blue mountains and the latter in the southwestern corner, extending into northern California, occupying what is now the Sis-

* American Geologist, vol. xxxii, pp. 267-308, 1903.

kiyou mountain region. The author traces the development of these islands into Oregon, and notes the changes of animal life as the development progresses. These islands each had a nucleus as early as the Triassic; they expanded through the Jurassic and had continuous increase in area through the Cretaceous.

The Cretaceous was closed by an important geologic and geographic event, the upfold of a colossal sea dyke. This dyke grew into the Cascade and Sierra Nevada range. It separated these islands, the Shoshone being enclosed on the east and thence forward associated with fresh water, and the Siskiyou on the west left still subject to marine conditions. This gave the islands different life histories, that of the Shoshone being characterized by land animals whose remains were washed into the lake in which the island stood, and that of the Siskiyou by beautifully preserved Eocene marine fossils. The Miocene was introduced by the slow initiation of the Coast range uplift, forming finally a Coast range valley between the Cascades and the Coast range which is traceable from southern California to Queen Charlotte's sound though having different names in its various parts—the San Joaquin, Sacramento, Willamette, Puget Sound.

The fresh waters on the east side of the Cascade uplift were gradually reduced in area, from lakes connected by streams to broad low valleys through which single streams flowed. These inland lakes laid the foundation for the drainage southward of the Colorado river, and that northward of the Columbia river. The Eocene climate was that of the palm and of the rhinoceros, moist and warm. The elevation and continuity of the Cascade range were not then sufficient to exclude the warm moist atmosphere of the Pacific. Much of the present area of Alaska, as pointed out by the author, was yet under the ocean, and there was presented an open passage for the Japan current, flowing eastward on its way to the Hudson bay and the coast of Greenland, thus "cutting off all accumulations of ice between Oregon and the Arctic ocean." These subtropical conditions were gradually changed to more temperate, and even Arctic, by the increasing elevation of the Cascades and the exclusion of the Japan current. This change was accompanied by the loss of the rhinoceros and the palm tree, the introduction of Miocene animals and plants and finally the Pliocene.

At the close of the Eocene the Shoshone island was joined to the eastern mainland. The larger mammals then swarmed over the island. These were Oreodon, Rhinoceros, Entilodon, Bothrolabis, various small rodents, cats like the cougar, dogs, diminutive horses having three hoofs instead of a single hoof, the composite genus Anchitherium.

With the introduction of the Pliocene the Miocene strata were slowly and unevenly elevated, the Miocene lakes were drained and large quantities of igneous rock were thrust upward through great orifices in the strata. The Pliocene lakes were smaller and their

sediments are marked by two characteristic fossils which run through them all, the camel and the horse. The horse was of numerous forms, the most noteworthy being Hipparion and Protohippus. The camel was in two groups, the camel proper and the Anchenia, the former perhaps as large as the Arabian camel and the latter about the size of a goat. Fossil remains of the real horse, indicating an animal about as large as a good sized dray horse of to-day have also been found in the Pliocene and were described by Prof. Condon in 1866, the earliest in North America.

The author divides the Pliocene of Oregon into two groups, the Dalles and the Silver Lake groups and gives notes of their vertebrate remains. It is in the latter that he found, associated with remains of camel and other Pliocene fossils, obsidian arrow points indicating that man lived in Pliocene time in Oregon. Prof. Cope accepted that conclusion, but Prof. Condon supposes that the case is not proven, since the human implements may have reached their position by simple gravitation through the denudation of some thickness of Pliocene strata which originally may have separated them from the camel bones. The existence of sand dunes in the immediate vicinity, suggesting powerful winds, and the fact that the bones and the arrow heads are mixed promiscuously on the bare surface, give some shadow of plausibility to this supposition. But it is plainly necessary to subject the region to an extensive and more detailed survey before it will be possible to pronounce positively on this question. *Prima facie* the evidence points as Cope concluded, but owing to the importance of the conclusion it may be best to hold it in abeyance.

The "surface deposits" are those that have accumulated since Pliocene time, bogs, swamps and all slight depressions in which large mammals often sink to their death. They are Pleistocene and contain the remains of mammoth, mastodon, the broad-faced ox and the sloth-like Mylodon. "A large part of this geological period overlaps that of prehistoric man." Up to the Glacial period the horse and the camel were abundant in Oregon and their continuance through Glacial times is still in doubt.

The author devotes a chapter to "The Willamette Sound." This body of water covered the Willamette valley and was connected with the Pacific. It was an incident of recent changes of level along the coast of Oregon and Washington. The sediments are thick, nicely stratified and in some places contain great numbers of fossils of recent shells mostly identical with those now living along the shore. The waters of this sound rose to at least 350 feet higher, relative to the land, than the Pacific ocean of to-day, and they buried the whole region under a fine loess which reaches the thickness of over 100 feet and forms the present soil and subsoil of the valley. The author does not indicate what may have been the chronological relation of this sound to the Pleistocene, or to any part of it. No human remains have yet been found in its sediments.

The latest geological event seems to have been the rise of the land to its present attitude, accompanied perhaps by volcanic activity in some of the peaks of the region.

The book is a very useful compend. It would have been improved by an index and still more by an outline map of Oregon. On the map could have been expressed various localities which the unfamiliar reader would have referred to eagerly, and it might also have shown some geological data. N. H. W.

Ice or Water: Another Appeal to Induction from the Scholastic Methods of Modern Geology. By SIR HENRY H. HOWORTH. In two volumes. Vol. I, pp. liii, 536; Vol. II, pp. viii, 498. Longmans, Green and Co., London, New York, and Bombay, 1905.

In these controversial volumes, published a few months ago, Sir Henry Howorth returns with redoubled zeal to his warfare against the glacialists. All extant or even obsolete theories of the causes of the Ice age are reviewed and analyzed. Weighed in the author's balance, they all are found wanting; none seems to him accordant with sound physical principles, and competent to explain continental glaciation. Therefore, in his judgment, the Ice age, in which the glacialists believe, must be a myth, merely a figment of their imagination.

To follow this destructive criticism, however, a constructive third volume is promised, completing the series thus entitled, which last volume will be devoted to exposition of the author's theory of the origin of the drift by the agency of rushing waters or floods, the renowned debacles of geologic science two or three generations ago.

From his early studies and publications, "A History of the Mongols," and "Chingiz Khan and his Ancestors," which led our author through central and northern Asia, he first came forward to challenge glacial doctrines in a memoir most amply illustrated by Siberia. This was "The Mammoth and the Flood, an Attempt to Confront the Theory of Uniformity with the Facts of Recent Geology" (pages xxxii, 464; London, 1887).

Six years later, he again assaulted these doctrines of glaciation, imputing them to wild imagination, such as gives affrighting dreams, in "The Glacial Nightmare and the Flood, a Second Appeal to Common Sense from the Extravagance of Some Recent Geology" (two volumes, pp. xxviii, 376, and xi, 377-920; London, 1893). In a considerable degree the new volumes cover the same ground and use the same arguments as that former work; but the present discussions and adverse criticism are more elaborate, with large polemic additions, brushing aside and toppling down, according to the author's opinion, all the ingenious devices by which the followers of Agassiz have sought to account for the climatic conditions of their Glacial period.

In opposition to the epeirogenic theory, which seems to the reviewer to be true and sufficient to explain the accumulation of

Pleistocene ice sheets, Sir Henry refuses its most important evidence and support by his denial that the fjords are valleys of river erosion. To his mind the great depths of the fjords beneath the sea level are not a proof of former high land elevation, because he regards these very deep meandering and branching valleys as fissures produced by rock fracture! But geologists can not give credence to this view of the origin of fjords, nor can they go back a century to the diluvial theory of the origin of till, moraines, and glacial striation. W. U.

The Rocks of Tristan d'Acunha, brought back by H. M. S. 'Odin', 1904, with their Bearing on the Question of the Permanence of Ocean Basins. By PROF. ERNEST H. L SCHWARZ, Rhodes University College, Grahamstown, South Africa. Transactions of the South African Philosophical Society, vol. xvi, pp. 9-51; with two maps and a section; May, 1905.

It is held by this author, following Judd and Suess, that the interior of the earth is composed of a heavy metallic center and is covèred by an envelope of siliceous slag. Where volcanic action reaches up from very great depths, it would therefore be expected to bring great masses of metallic substances, like the nickeliferous iron of Ovifak in Greenland. But in no instance has an oceanic island of volcanic rocks yielded a mine of any metal. Nearly everywhere the seat of volcanic upflow appears to be of relatively small depth, where the motion and friction of bending and shearing along great fissure lines have melted parts of the sedimentary or older crystalline rocks of the earth crust.

On the lofty island of Tristan d' Acunha, and on numerous other lone volcanic islands of the South Atlantic, fragments of granite, gneiss, or other rocks of continental types, have been found, leading to the hypothesis that formerly a continental land mass occupied that area, which is now enveloped by profound oceanic waters. The ancient land is supposed to have reached from Cape San Roque to Sierra Leone, on the north, and from southern Brazil through Tristan d' Acunha, to the Cape of Good Hope, on the south; and it is conjectured to have existed from Devonian to Late Tertiary times. W. U.

Geological Survey of New Jersey, Annual Report for the Year 1904. HENRY B. KUMMEL, State Geologist. Pages ix, 317; with 19 plates and 18 figures in the text. Trenton, N. J., 1905.

Besides his administrative report, the state geologist writes of the molding sands and the mining industry. The production of iron ore from the New Jersey mines in 1904 was nearly half a million tons, being greater than in any former year since 1891; and the zinc ore production was 250,025 tons.

Dr. Charles R. Eastman presents a report on the Triassic fishes of New Jersey, noting sixteen species.

Stuart Weller describes the fauna of the Cliffwood clays in the Raritan formation, and classifies the Upper Cretaceous formations and faunas of the state.

F. B. Peck treats of the talc deposits of Phillipsburg, N. J., and Easton, Pa.; and Arthur C. Spencer reports the progress of work in the Pre-Cambrian rocks. W. U.

The Geology of the Perry Basin in Southeastern Maine. By George Otis Smith and David White. U. S. Geol. Survey, Professional Paper No. 35. Pages 107, with 6 plates. 1905.

The earliest report of Dr. Charles T. Jackson on the geology of Maine, in 1837, recommended boring for discovery of coal in the sandstone formation bordering the west side of Passamaquoddy bay, in the vicinity of Perry, that formation being supposed to be a continuation of the bituminous coal series of New Brunswick. Later, on the evidence of fossil plants, the Perry beds were regarded by W. B. Rogers, Newberry, C. H. Hitchcock, J. W. Dawson, and others, as of upper Devonian age, being thus older than any known rocks containing commercially workable coal. But citizens of that district, deeming the question yet undecided, petitioned the state legislature two years ago for an appropriation to be expended in drilling for coal, which led to the special survey reported in this paper.

The Perry formation is found to comprise, in ascending order, a lower conglomerate, a lower lava, an upper sandstone, and an upper lava. There has been no very marked folding and but slight alteration of the beds; and their age is shown to be distinctly upper Devonian, and probably Chemung. It is certain that they contain no workable coal deposits. W. U.

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PERSONAL AND SCIENTIFIC NEWS.

PROF. RIES OF CORNELL UNINERSITY has been engaged during the summer, on an investigation of the clays and molding sands of the Virginia coastal plain.

W. T. MCCOURT, INSTRUCTOR IN ECONOMIC GEOLOGY in Cornell university, has been studying the peat deposits of New Jersey for the N. J. Geol. Survey.

MR. H. FOSTER BAIN is engaged in a study of the Rocky mountain zinc fields for the U. S. Geol. Survey. He will visit Colorado, New Mexico and other producing territories to arrange for the collection of statistics of production for the Division of Mineral Resources.

PROFESSOR T. C. CHAMBERLIN has been appointed a member of the Illinois Geological Survey Board. The remaining members are ex-officio, governor Deneen and president James of the State university..

MR. BAILEY WILLIS returned in July from Europe where he had been since February working under a grant from the Carnegie Institution.

DR. C. W. HAYES of the U. S. Geological Survey spent July and August in Utah and other western states inspecting field work.

PROF. EDWARD ORTON JR, State Geologist of Ohio, spent three weeks in July studying the glacial geology of Longs Peak, Colorado. The remainder of the summer he will spend in Massachusetts engaged in editing one of the bulletins of the state survey. Field work for the Geological Survey of Ohio is being carried on by other members of the survey. Prof. John A. Bownocker is studying and mapping the Pittsburg coal in eastern Ohio and completing a bulletin on the salt fields and industry of the state. Prof. Charles S. Prosser is studying the Devonian and Carboniferous formations of the state and part of the summer will be spent on his report on the stratigraphical geology of these formations.

DURING THE MONTH OF JULY Mr. M. L. Fuller and F. G. Clapp of the United States geological survey made a reconnaissance trip through Newfoundland and along the coast of Labrador to a point north of Hopedale for the purpose of comparing the glacial features with those of northeastern United States. Several interesting points relating to possible pre-Wisconsin deposits, to the origin of the high terraces and to the recentness of the last glaciation, were brought out. The intention was to go further north, but this was impossible because of the presence of unusually heavy pack ice along the shore from which the vessel was obliged to withdraw after penetrating it for a distance of some ten miles.

HEAD OF JAMESVILLE CHANNEL LOOKING NORTHWEST. SITE OF GLACIAL CATARACT.

THE
AMERICAN GEOLOGIST.

VOL. XXXVI. SEPTEMBER, 1905. No 3.

PLEISTOCENE FEATURES IN THE SYRACUSE REGION.*

By H L. FAIRCHILD, University of Rochester

PLATES VI. AND VII.

The district lying near the city of Syracuse is one of unusual interest to the student of glacial and geographic geology. In addition to the common forms of Glacial drift there are here displayed a remarkable series of stream canons and cataracts cut by the ice-border drainage, and the shore phenomena of Glacial lakes, specially of lake Iroquois.

Moraines are not strongly represented among the drift forms of the region. No heavy or well-defined moraine occurs near the city, although some masses of hummocky drift are to be seen. Most of the drift burden of the ice sheet was here built into drumlins. Valley moraines occur far south of the city, as has been noted in the description of the railroad routes.

Kames, or water-laid or stratified drift in the form of knolls or mounds of gravel and sand, are scattered over the region, and are conspicuous in the southern part of the city and along the valley sides, their structure being well shown in the excavations for building sand.

The remarkable features of the drift known as "drumlins" are excellently shown in and around the city. The city lies in the eastern end of the belt of drumlins, perhaps the most remarkable in the world, which extends west for a hundred miles. Every hill between Syracuse and Rochester is a drumlin; although some of them have a base or core of Salina shale.

* Prepared for the field programme of the meeting of Section E, Am. Assoc. Adv. Sci., Syracuse, N. Y., July 19-22, 1905.

South of the palallel of Syracuse, which lies at the line of the north-facing escarpment of the Onondaga limestone, the ancient valleys that were cut by north-flowing streams are very prominent, the country being a series of north and south valleys and intervalley ridges, a part of the "finger lakes" area. North of the parallel of Syracuse, and where the strata are mostly a great thickness of soft Salina, Niagara and Medina shales, the valleys have been obliterated, partly by the drift filling, and possibly to some extent by the removal by the ice of the saliences in the soft Salina. The city lies in the northern end of the visible Onondaga valley, on a plain produced by Glacial and lake filling. Deep borings for salt show a great depth of valley filling, but the topography of the buried valley can only be determined by systematic borings. In the deeply buried sands of the valley the brines accumulate from the adjacent salt beds, making Syracuse the "saline city."

During the recession of the continental glacier from this region, the ice sheet acted as a barrier to the northward drainage by blocking the northern ends of the valleys. In consequence, lakes were held in all the valleys extending southward into the highland. The earliest and highest waters in each valley found escape southward across the col at the present valley head; but later, as the ice front gave way, the overflow was across the intervalley ridges past the ice border. The evidences of these ancient waters are the deltas built at various levels by the tributary streams, and the outlet channels which determined the several levels. Some of these channels and correlating deltas are very prominent features.

The description and naming of the local lakes in the valleys of the Syracuse region may be found in pages 52-63 of the article noted in the list of references as No. 1. As this may not be available to all readers, a brief enumeration of these lakes is given as follows: In the Otisco valley the primitive and highest water, called the Glacial lake Otisco, had its outlet southward over the col. The lower water, the Mariette lake, escaped west to the Skaneateles valley. In the Onondaga valley the highest water was the Cardiff lake, which had its outlet south through the Tully lakes. Later,

the waters fell to the hight of the outlets at Joshua and Navarino, leading west to the Otisco valley, and are called the South Onondaga lake. A yet lower lake, the Onondaga Valley lake, had eastward escape by the channels at Jamesville. On the Butternut valley the highest lake, Butternut lake, overflowed south across the col and through Tully village, while its successor, the Jamesville lake, had outlet eastward by the channels northeast of Jamesville.

The vast expanse of Glacial waters which were held by the waning ice sheet in the Huron, Erie and Ontario basins had their lower escape through the lower members of the local lakes already mentioned. These were the great lake Warren and the lowering waters, of which only one pause had been determined, namely: lake Dana. The Warren waters reached this territory with an altitude of about 890 feet as the present level. The Dana waters were about 180 feet lower, and the outlet of lake Dana is believed to be the great channel leading east from Marcellus. The numerals given in connection with the channels shown in the accompanying map, show the present altitude of the heads of the channels. (Plate vii.)

The successor of the Warren water and the falling Warren (Hyper-Iroquois) in the Ontario is lake Iroquois, with its outlet at Rome over the Mohawk valley. Lake Iroquois flooded the Syracuse plain and the lower ends of the Onondaga, Butternut and Limestone valleys. The wave-cut notches on the drumlins and the wave-built spits and bars are to be seen near the city.

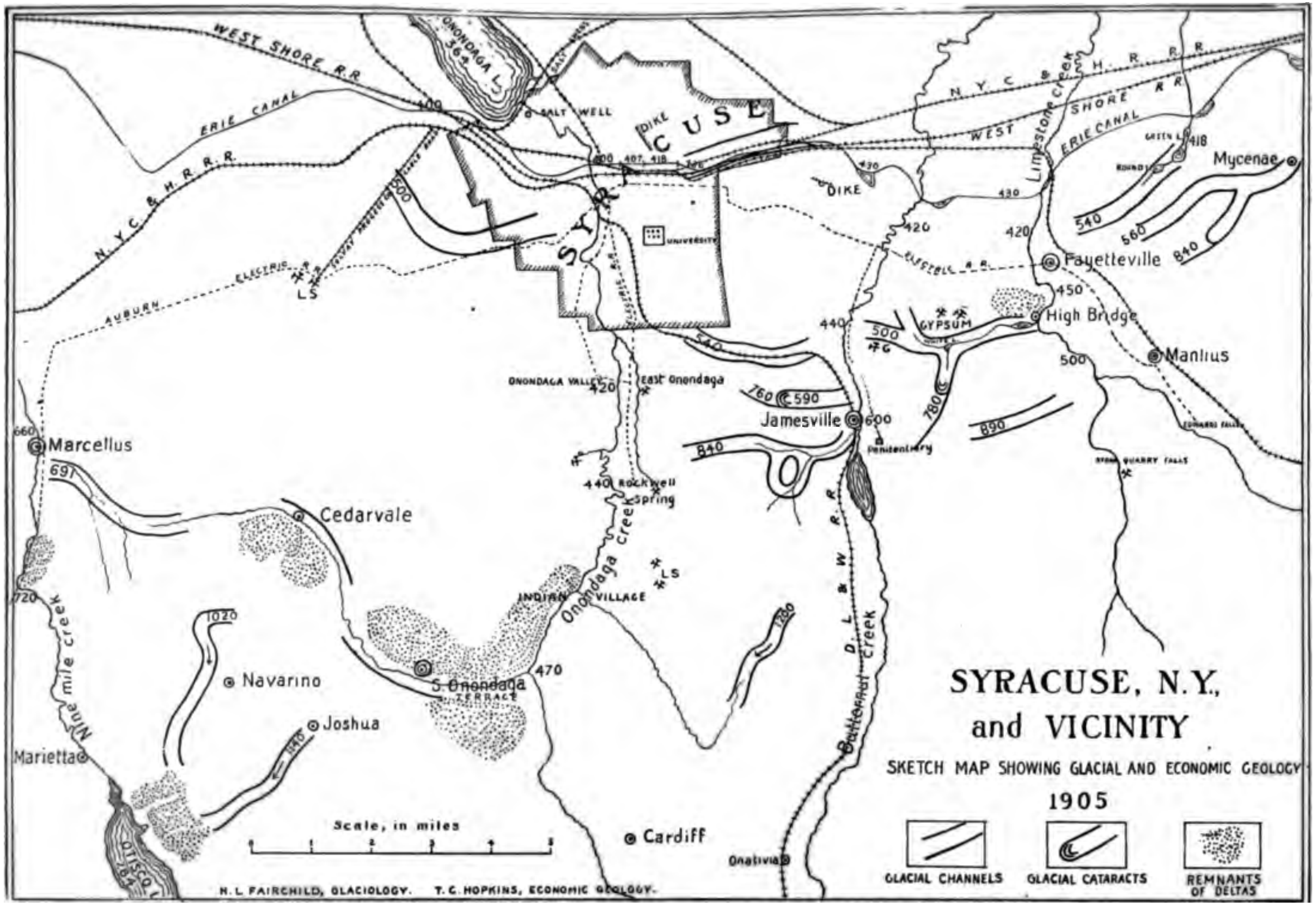
The most novel and interesting features of the region are the deserted river channels, which were cut by the Glacial waters in their escape to the eastward past the ice border. After the glacier had dumped its rock-rubbish in the valleys and so formed the valley-head moraine, or present water parting, it wasted away until the ice border was many miles north of the moraines, thus forming the valley basins that held the local Glacial lakes described above, the northern barrier being the ice body itself. The later waters held in these basins escaped across the ridges and produced the fossil channels that are indicated in the map. The reader should clearly understand that the present

north-flowing streams are in deep and wide pre-Glacial valleys (these are shown by the topographic sheets), while the extinct channels are cut across the tops of the inter-valley ridges and high above the north-south valleys. In other words, the highest of them have both ends in the air. As the crests of the ridges decline or fall away to the north, the transverse channels on any meridian were cut successively from south to north, as the ice barrier receded, and of course at successively lower levels. As no channel was deserted until a lower escape was opened. it follows that each successive or lower channel must have been initiated at an altitude below the bottom of the preceding channel.

The Syracuse channels and cataracts were functionally the predecessors of Niagara, as they carried the overflow of western waters eastward to the Ontarian level. Two of the fossil cataracts. those of Jamesville and Blue lakes, are comparable in hight and capacity to the present Niagara. No visitor, standing for the first time on the crest of the Jamesville lake amphitheater and appreciating the romantic history involved in the phenomena, will regret a journey of a thousand miles to view the region. (See plate vi.

A brief description of these features, with illustrations, may be found in No. 3 of the references.

The rivers which excavated the cross-ridge channels dumped their detritus into the valley lakes. A very prominent delta lies two miles south of Marcellus. in the Otisco valley. but this is beyond the easy reach of the excursions. It may be seen on the Skaneateles sheet. The largest delta in the region is in the Onondaga valley at the junction of the Marcellus-Cedarvale channel, and shows on the Tully sheet. It can be reached on the trips and can be plainly seen miles away. from the east side of the Onondaga valley. This great delta extends from a mile northwest of South Onondaga around the north of Indian Village, a stretch of four miles. Another delta lies west of Jamesville at the mouth of the gorge, below the lake and ancient cataract. Still another and more conspicuous delta occurs at High Bridge in the limestone valley at the mouth of the White lake channel. and is mapped in the southeast corner of the Syracuse sheet. Small terraces and benches of stream detri-



SYRACUSE, N.Y., and VICINITY
SKETCH MAP SHOWING GLACIAL AND ECONOMIC GEOLOGY
1905
GLACIAL CHANNELS
GLACIAL CATARACTS
REMNANTS OF DELTAS
Scale, in miles
H. L. FAIRCHILD, GLACIOLOGY. T. C. HOPKINS, ECONOMIC GEOLOGY.
WEST SHORE R.R.
ERIE CANAL
N. Y. C. & H. R. R. R.
ONONDAGA L. 364
SALT WELL
SYRACUSE
DIKE
UNIVERSITY
AUBURN
ELECTRIC R. R.
Marcellus
Cedarvale
Navarino
Joshua
Marietta
Nine mile creek
OTISCO L. 784
S. Onondaga
TERRACE
INDIAN VILLAGE
Onondaga creek
Rockwell Spring
East Onondaga
ONONDAGA VALLEY
Cardiff
Onativia
Jamesville
Penitentiary
D. L. & W. R. R.
Butternut Creek
GYPSUM
High Bridge
Fayetteville
Manlius
Mycenae
Limestone creek
GREEN L.
ROUND L.
STONE QUARRY FALLS
EDWARDS FALLS

tus, built in the Glacial waters, may be seen along the slopes of the valleys, correlating with the lake levels established by the stronger channels. Those in the Onondaga valley are more specially related to the Railroad channel.

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   Gives a description of the Glacial lakes, with illustrations.
2. Amer. Jour. Sci., vii: 249-263.
   Describes the Glacial lakes Newberry, Warren and Dana.
3. 20th Ann. Rep. N. Y. State Geologist, 1900, pp. 112-129.
   Describes and illustrates the extinct channels and cataracts in the Syracuse region.
4. 21st Ann. Rep. N. Y. State Geologist, 1901, pp. 33-47.
   Describes and illustrates the lower channels between Syracuse and Rome, especially the channel which passes through the city of Syracuse.
5. 22nd Ann. Rep. N. Y. State Geologist, 1902, plate 1, facing p. 19.
   Map with description of lake Warren.
6. Bulletin Geol. Soc. Am., ix: 173-182.
   Description by E. C. Quereau of the Jamesville lake and surroundings.

CAR-WINDOW GEOLOGY: SUGGESTIONS TO TRAVELERS.

Approaching Syracuse from the west by the New York Central or the West Shore railroad,—From Buffalo to Crittenden the New York Central R. R. lies on the leveled lake-bottom of Warren waters, the strong beach of which is crossed at Crittenden. From there to beyond Batavia the road is in the well-accentuated Batavia moraine. From there to Rochester the generally smooth plain is diversified with drumlins and low kames. The West Shore road lies on the Warren lake-bottom nearly all the way, and at Smithville station a conspicuous cliff cut by Warren waves may be seen on the south. From Oakfield to Rochester scattered drumlins may be seen on the south. From Oakfield to Rochester scattered drumlins may be seen on the south, with moraine topography at Churchville.

From Fairport (east of Rochester) to and beyond Syracuse these railroads follow the river channels cut by the Glacial waters in their eastward flow. From Newark eastward the work of lake Iroquois waves may be seen in numerous notches or terraces on the drumlins, at from 20 to 30 feet above the level of the railroads. For the whole

distance the drumlins appear in remarkable form. The Salina shales appear in places as red or green clay-like exposures, the best display being 3 miles east of Newark, on the south side of the tracks.

Approaching Syracuse from the east by the New York Central.—From Schenectady to Rome the railroad lies in the ancient channel of the Iromohawk river, a stream larger than the St. Lawrence, which carried the overflow of the Glacial lake, lake Iroquois. On the south wall of the valley may be seen the high-level channels cut by Glacial waters when held up by the ice front. Such are conspicuous three or four miles west of Little Falls and east of Utica for several miles. Between Little Falls and Rome the deltas built in the earlier waters and the flood plains of the Iromohawk are conspicuous. (This stretch is covered by the Utica, Oriskany and Oneida sheets of the geological map of New York State.) From Rome to near Oneida the railroad lies in a pronounced Glacial river channel. All the way from Oneida to Syracuse the tracks lie on the Iroquois lake-bottom, while the south banks of the ice-border drainage are conspicuous at many points, on the south side of the train appearing as steep bluffs on the saliences. The north bank of the stream was the ice of the ancient Glacial cap.

The West Shore railroad parallels the New York Central from Oneida to Syracuse and shows the stream-cut bluffs even better, since it lies farther south.

Approaching Syracuse from the south by the Delaware Lackawanna and Western railroad.—Northward from Binghamton the road follows valleys which were the southern escape of Glacial waters. The abundant stream detritus may be seen in the broad stretches of gravel plains and in terraces and deltas at the mouths of side valleys. From Tully northward for two miles the road lies in the small channel across the col which was the outlet of the Butternut Glacial lake. From Apulia to Jamesville the road lies high on the west side of the Butternut valley and commands a fine view of the valley features. For three miles north of Apulia the valley is partly filled with moraine drift. Opposite Onativia broad delta terraces are seen on the east side, which correlate with the Tully outlet. Moraine drift is

conspicuous, either in the valley bottom or banked against the walls. (The Tully sheet covers all this area.)

Between Jamesville and Syracuse the road passes through the grandest of the ancient river channels, the "Railroad" channel, which is a fourth of a mile wide and 150 feet deep, mostly in Onondaga limestone. (Syracuse sheet.)

Approaching Syracuse from the North —The two branches of the Rome, Watertown and Ogdensburg railroad, and the Oswego division of the Delaware, Lackawanna and Western railroad leading into Syracuse from the north, all lie on the Iroquois lake-bottom but encounter few striking features, though all the ordinary forms of drift appear. At the junction of the two branches of the Rome, Watertown and Ogdensburg at Woodward, the railroad cuts across a heavy ridge or bar of lake Iroquois (Syracuse sheet). From Adams Center south to Richland Junction, more than 20 miles, the R., W. & O. lies on the west (lakeward) side of the heavy Iroquois beach, carrying a "ridge road." (Pulaski, Sacketts Harbor and Watertown sheets.)

Approaching Syracuse from the west by the Auburn branch of the New York Central railroad—At Victor this line is in a great channel of Glacial flow, which it again traverses from Clifton Springs through Phelps to near Geneva. At Halfway Station it enters another striking channel, which it follows through Camillus to near Syracuse. This is on the Baldwinsville sheet.

NOTES ON THE PERMIAN FORMATIONS OF KANSAS.

By CHARLES S. PROSSER, Columbus, Ohio.

In 1902 the writer reviewed the recent literature regarding the correlation of the upper Paleozoic of Kansas with the Russian Permian.* In this review the writer inadvertently omitted reference to the papers of Dr. E. H. Sellards identifying and describing Permian plants from Kansas, although he was familiar with them. In 1900 Dr. Sellards reported the identification of *Callipteris conferta* Sterng. from the Marion formation (or possibly the lower part of the Wellington shales) of Dickinson county in eastern central Kansas and the geological importance of this discovery was discussed as follows by him:

"The geological range of *Callipteris conferta* has an interesting bearing on the question of the age of the uppermost Paleozoic rocks of Kansas. The species is characteristic of the middle and lower Rothliegenden of Europe, but has not been found above the middle of the Permian. It has also been found in the Permo-carboniferous of West Virginia. The occurrence of this species near the top of the Kansas strata [in Dickinson county only the Big Blue series or lower Permian occurs; the Cimarron series or upper Permian is found farther south] together with *Sphenophyllum*, a genus that has not been discovered above the middle of the Permian, makes it improbable that the Kansas beds are younger than middle Permian. While, on the other hand, the presence of *Callipteris*, a Permian genus, and the number and variety of plants belonging to the Tæniopteroid group, as well as the general character of the flora, tends to confirm the Permian age of the Kansas Upper Paleozoic."†

In 1900 fossil plants were found in the Smoky Hill river valley just east of Salina in Saline county, which adjoins Dickinson county on the west, in rocks of about the same age as those of the former locality. In commenting upon the plants from both of these localities Dr. Sellards said:

"There are, in the collections so far made, some twenty-six or twenty-seven determinable species, distributed in fourteen genera. The plants indicate unmistakably the true Permian age of the formation in which they are found. Many of the species are characteristically Permian, and only a very small proportion of the species identical with Upper Carboniferous species."*

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* Jour. Geol., vol. x, pp. 721-737.
† Bull. Univ. Kansas, vol. i, No. 2 (Kan. Univ. Quarterly, vol. ix, No. 1), p. 64.
* Trans. Kansas Acad. Sci., vol. xvii, 1901, p. 209.

Part of this flora has been described by Dr. Sellards† and in the second paper he identifies and describes *Tæniopteris coriacea* Goep. which he states:

"Seems to have been found as yet in only two other localities, both Permian, Ottendorf in Bohemia, and Lissitz in Moravia."‡

In 1903 Dr. Keyes published a paper entitled "Some recent aspects of the Permian question in America,"† in which he objected to certain statements in my article of the previous year. His principal objection, apparently, was that in giving the "Classification of the upper Paleozoic formations of Kansas" the writer used Cragin's name of Big Blue instead of Keyes' term Oklahoman for the lower series of the Permian and stated that in Kansas they were identical. The following brief history of these two terms will furnish a basis for judging whether it was a fair statement or not. The term "Big Blue series" was proposed by professor Cragin in March, 1896, for the lower Kansas Permian formations‡ which he listed as follows:

Wellington shales.
Geuda salt-measures [which later he withdrew in favor of the name Marion formation]*
Chase limestones.
Neosho shales.†

Professor Cragin stated that

"It may be called the Big Blue series, from the Big Blue river, which in northern Kansas crosses the somewhat narrowed northern extension of its area of outcrop."‡

The upper Permian formations, popularly termed the Red Beds, were named the Cimarron series by professor Cragin in the same article.§

In July, 1896, Dr. Keyes proposed "to recognize in the 'upper' Carboniferous of the western interior province three series having equal taxonomic rank," the upper two of which in ascending order were named the Missourian and Oklahoman.* The top of the Cottonwood limestone was

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† Bull. Univ. Kansas, vol. i, No. 4 (Kan. Univ. Quarterly, vol. ix, No. 3), 1900, p. 179 and *ibid.* vol. ii, No. 1, (Kan. Univ. Quart., vol. x, No. 1), 1901, p. 1.
* *Loc. cit.*, p. 3.
† Am. Geol., vol. xxxii, p. 218.
‡ Col. Coll. Studies, vol. vi, March 27, pp. 3, 5, 6.
* Am. Geol., vol. xviii, Aug., 1896 p. 132.
† Col. Coll. Studies, vol. vi, p. 3.
‡ *Ibid.*, p. 6.
§ *Loc. cit.*, pp. 3, 18, 48; see additional account in Am. Geol., vol. xix, May, 1897, pp. 351-364.
* Am. Geol., vol. xviii, p. 25.

given as the upper limit of the Missourian series and in defining the series it was stated that

"In suggesting the name Oklahoman as a serial geological term it is intended to apply to all those rocks of Carboniferous age which occur north of the Canadian river in Oklahoma and which lie between the interval of the top of the Missourian series and the base of the Cretaceous. It may be regarded as essentially covering the same succession of strata that has long been vaguely known under the title of 'Permian.' The name is derived from the territory in which the formation has its best development and in which the most complete sequence is represented. The best sections across the belt appear to be exhibited along the Cimarron, Arkansas and Kansas rivers, and these sections may be considered typical."[*]

In October, 1901, Dr. Keyes accepted the name Cimarron series for the Red Beds[†] and gave the upper three series of the Carboniferous in ascending order as the Missourian, Oklahoman and Cimarron[‡] stating their respective stratigraphic values as 4, 2 and 1.[§]

The following month Dr. Keyes published a "General Geological Section of the Carboniferous of the Mississippi Valley," in which a complete list of the series and terranes of the system is given. For the portion under consideration it is as follows:

	Series.	Terranes.
Carboniferous system. [Upper portion]	Cimarron.....	Kiger shales. Salt Fork shales.
	Oklahoman....	Wellington shales. Marion limestone. Chase limestone. Neosho shales.
	Missourian [Upper part]	Cottonwood limestone. Atchison shales. [Wabaunsee of Prosser][*]

It will be seen from the above quotation that the terranes listed by Dr. Keyes as composing the Oklahoman series are entirely Kansas formations and precisely the same as those given by professor Cragin for the Big Blue series. It was this agreement which led the writer in his "Classifi-

* *Ibid.*, p. 27.
† Am. Jour. Sci., 4th ser., vol. xii, p. 309.
‡ *Ibid.*, pp. 306, 309.
§ *Ibid.*, p. 306.
* Am. Geol. vol. xxviii, Nov., 1901, p. 302.

cation of the upper Paleozoic formations of Kansas" to state that

"It will be seen that the Oklahoman series, as precisely defined above, is identified with the Big Blue series proposed by Dr. Cragin in 1896, and therefore his name, which has priority, is adopted for this classification."†

Dr. Keyes in discussing my paper has objected to the above interpretation and made certain statements regarding the limits of the Oklahoman series. He says: "When the title Oklahoman was first proposed for the uppermost series of the Carboniferous its upper limits were not very definitely fixed—further than it was stated that in a general way the terrane corresponded to what had previously been called Permian. At that time the Red Beds were regarded as post-Carboniferous in age."‡

The original statement of Dr. Keyes in 1896, when he first defined the Oklahoman series is as follows:

"In suggesting the name Oklahoman as a serial geological term it is intended to apply to all those rocks of Carboniferous age which occur north of the Canadian river in Oklahoma and which lie between the interval of the top of the Missourian series and the base of the Cretaceous. * * * Although there has been little detailed study in the region regarding the relations of the series under consideration and the Cretaceous above, it is well known that the latter rests in marked unconformity upon all four series of the Carboniferous and at the north extends over still older formations."*

The writer has given a fairly complete historical review of the correlation of the Red Beds or Cimarron series of Kansas† and the following brief statement of the most important changes in their correlation will be of interest in connection with the above quotation. In early papers the Red Beds were frequently called Cretaceous and correlated with the Dakota sandstone. In 1887 professor St. John referred them with a query to the Triassic system.‡ For several years subsequent to this report the age of the Red Beds was generally given as either Triassic or Jura-Trias. In 1893, however, professor Hay changed his correlation of the Red Beds of Kansas to the Upper Permian on account of the discovery of Permian fossils in Texas in beds which he considered as of similar age.*

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† Jour. Geol., vol. x, 1902, chart opposite p. 718.
‡ Am. Geol., vol. xxxii, Oct., 1903, p. 219.
* Am. Geol., vol. xviii, p. 27.
† Univ. Geol. Surv. Kansas, vol. ii, 1897, pp. 75-83.
‡ Fifth Bien. Rept. Kansas State Board Agr., pt. ii, pp. 140, 141.
* Eighth *ibid.*, pt. ii, pp. 101, 108.

In March, 1896, professor Cragin named the Red Beds of Kansas, the Cimarron series, published a detailed account of it, which he unhesitatingly referred to the Permian system, and subdivided it into ten formations.‡ It will thus be seen that for some years previous to the proposal of the Oklahoman series by Dr. Keyes in July, 1896, the Red Beds of Kansas had generally been considered by geologists as belonging in the Jura-Trias, the Triassic or the Permian. It is also evident from Dr. Keyes' original definition of Oklahoman that for part of the territory he had in mind for its upper limit the base of the true Cretaceous, so that it was an open question whether he intended or not to include in it the Red Beds. It is interesting to note in this connection that in November, 1904, in a "Generalized geological section for New Mexico" Dr. Keyes gave the age of the "Cimarron formation" as Triassic* although Dr. Beede more than three years before had shown conclusively from fossils that in its typical area the greater part of the Cimarron series is of Paleozoic age.†

Dr. Keyes in his paper of 1903 indicates the limits of the Oklahoman series in the following manner:

"As it now appears, even according to professor Prosser's published data, the Oklahoman in central Kansas includes at the base at least one important formation more than the Big Blue series; and at the top at least one formation less. The Oklahoman series in Kansas is delimited above by the top of the Marion limestones. In my various papers, with one exception due to a typographical error arising from inability to see the proof sheets of the article, this fact is clearly indicated. This is particularly emphasized in the memoir frequently quoted by professor Prosser, on the detailed comparison of the Upper Carboniferous of Kansas with the Russian Permian."*

It has already been shown that the basal formation of the Oklahoman series as defined by Dr. Keyes is the Neosho shale,† which is also the lowest formation of the Big Blue series as defined by Dr. Cragin.‡ It is, therefore, clear that the basal limit of the Oklahoman and Big Blue series as de-

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‡ Col. Coll. Studies, vol. vi, pp. 1-5, 48.
* Am. Jour. Sci., 4th ser., vol. xviii, p. 360.
† Jour. Geol., vol. ix, July, 1901, p. 339.
Am. Geol., vol. xxviii, July, 1901, pp. 46, 47.
Adv. Bull. First Bien. Rept. Oklahoma Geol. Surv., April, 1902, pp. 1-11.
* Am. Geol., vol. xxxii, pp. 219, 220.
† Am. Geol., vol. xxviii, 1901, p. 302.
‡ Col. Coll. Studies, vol. vi, 1896, p. 3.

fined by their respective authors is the same. This is not changed by the fact that in my paper of 1902 the Neosho shales were made the upper division of the Missourian rather than the lower division of the Big Blue series.

Dr. Keyes in 1903 clearly states that the top of the Oklahoman series is marked by the top of the Marion limestones and apparently states that the inclusion of the Wellington shales in it in November, 1901, was due to a typographical error.§ The paper just cited gave no evidence of such error and at the time of the publication of my classification in 1902 Dr. Keyes had made no statement which clearly indicated such error. The paper cited as the one in which Dr. Keyes "particularly emphasized" this line is apparently the one on the "American homotaxial equivalents of the original Permian."* In this article there are two portions which bear upon the point in question. First, Dr. Keyes gave a table entitled "Comparison of general sections" in Russia and the Mississippi valley which is as follows for the upper Paleozoic rocks:

RUSSIA.	CHARACTER OF TERRANES.	MISSISSIPPI VALLEY.	
Tartaran, Permo-Trias, or Upper Permian, P^4..............	Shales and marls, red and variegated, shaly sandstones; fossils rare; "Red Beds."	Cimarron Series.	
Middle Permian, P^2....	Limestones, some dolomitic, separated by calcareous marl	(Marion li.)	Series.
Lower Permian P1—b..	Shales (only 200 feet thick in Kama Valley.)	————?	
Upper Permo-Carboniferous (base of original Permian) C Pc.	Limestone, heavy dolomitic.	(Chase li.)	
Artinsk, C P....	Shales, sandstones, some thin limestones.	(Neosho) (Cottonwood) (Wabaunsee)	Series.
Upper Carboniferous, C^3.......	Limestones and shales, highly fossiliferous.	Missourian Series.	

§ Am. Geol., vol. xxviii, p. 302.
* Jour. Geol., vol. vii, 1899, pp. 321-342.
* *Ibid.*, p. 332.

The second paragraph of this division of the paper treating of the classification of this part of the rocks is as follows:

"The uppermost division of the Paleozoic of the region, the part widely designated as the 'Red Beds,' has received the title of Cimarron series. It appears to form a tolerably compact sequence, though there is still some dispute as to its exact geological age. Between the Cimarron series and the Missourian series are two other terranes that are well defined. One is composed of the Chase and Marion of Prosser, in part, and the other of the Wabaunsee, Cottonwood, and Neosho."*

It will be seen from the above quotations that it is not definitely stated that the Wellington shales are put in the Cimarron series. Again, the name Oklahoman series does not appear in the paper; the top of the Missourian series is drawn from 500 to 550 feet lower than in his former papers and the rocks between the Missourian, as there limited, and Cimarron series are divided into two series which are not named and clearly neither one nor both together agreed with the Oklahoman series as previously defined. The writer attempted to represent the views of Dr. Keyes fairly and, if he failed, it appears to him that it was partly due to the lack of clearness in the statements made by Dr. Keyes.

The writer, however, objects to the last paragraph of Dr. Keyes' paper which is not a fair statement. It is as follows:

"A singular argument does professor Prosser use to retain the title of Permian as the name of a system and period. He refers to half a dozen Russian writers who have used the title in this sense. No allusion whatever is made to a much larger number of Russian geologists who are equally distinguished and who all have worked extensively in the typical regions, but who hold very different views. This method of presentation is hardly the scientific method."*

As a matter of fact the writer took the later official reports of the Russian survey† so far as he was able to obtain them, and gave a very condensed but impartial statement regarding the classification of the rocks under consideration.

* *Loc. cit.*, p. 339.
* Am. Geol., vol. xxxii, p. 223.
† In obtaining references to various articles in the *Mémoires du Comité géologique de Saint-Pétersbourg* describing the upper Paleozoic the writer availed himself of the copious foot notes in volume ii of Suess' "La face de la terre." Margerie's translation, 1900, and references in Frech's "Lethaea palaeozoica."

There was no change, selection or elimination and if it favored the views which the writer expressed, such was the concensus of the evidence before him. At that time, however, the writer inadvertently overlooked the following statement of Nikitin, the well-known Russian authority on the Carboniferous: Finally the Americans, as is known, generally refer, contrary to European geologists, the so-called Permo-Carboniferous of Mr. Meek to the Carboniferous system.*

Regarding the correlation with and retention of the name Permian for the upper American Paleozoic deposits the writer in 1902 made the following statement:

"The number of American geologists who believe that these Upper Paleozoic formations should be correlated with the Permian and given the rank of a period or system is probably still smaller than the number of those who would retain the name Permian but classify it as the upper series of the Carboniferous. * * * It has appeared to me, however, that the weight of evidence favored correlating the upper formations with the Permian."†

Since the publication of the above paper additional evidence favoring the correlation of the upper Paleozoic deposits of Kansas with the Permian has been received. The following brief summary will give an idea of its nature:

In January, 1903, Dr. Sellards wrote me as follows:

"The fossil plants in my opinion support your belief in the existence of true Permian in Kansas (below the Red Beds). The flora of the Marion (or Wellington) differs specifically almost *in toto* from that of formations as low down as the Lawrence shales [which occur near the middle of the Missourian series of Dr. Keyes and form the lower member of professor Haworth's Douglas formation] and indicates as I have already stated (Kan. Acad. Sci., 1900; Kan. Univ. Bull., vol. 9, Jan., 1900) a lower Permian age. The plants in this case are pretty conclusive and the genera and species are identical with or most closely related to those of the lower Permian of Europe."*

Dr. Sellards has also found insects exceptionally well preserved in the Marion formation in the southern part of Dickinson county. He also states that

"A considerable number of insects had been previously obtained from the Coal Measures near Lawrence, Kansas"

and he contrasts these two insect faunas as follows:

* Mém. Comité Géologique, vol. v, No. 5, 1890, p. 152.
† Jour. Geol., vol. x, p. 728.
* Letter of Jan. 12, 1903.

"The insects from the Marion seem on the whole very different from those of the Lawrence shales and other Coal Measure deposits. The Coal Measure insects, as far as known, are on the average large; on the contrary, most of the Marion species are small. Cockroaches at this new locality are much in the minority. Of some six hundred specimens collected, not more than about sixteen are cockroaches and these are of small size and belong for the most part to the Coal Measure and Permian genus, *Etoblattina* Fossil plants were discovered in the Marion in 1899. The collections made from the Marion and Wellington (?) during 1899-1900 seemed to the writer at that time to indicate a lower Permian flora. These collections have since been increased, and it may now be said with a good deal of confidence that, although a few species have survived from the Upper Coal Measures, the Marion contains on the whole a distinctly Permian flora. The marked change in the insect fauna in passing from the Lawrence shales to the Marion formation is therefore paralleled by the plant evolution."†

The evidence furnished by fossil plants regarding the correlation of the upper Paleozoic formations of Kansas has been reviewed by Dr. David White. His conclusions concerning two of these floras are important in reference to the identification of the Permian. The lower of these floras is from the Elmdale formation (which in the writer's classification is put in the Wabaunsee stage of the Missourian series, beginning about 200 feet below its top) at Onaga, in the northeastern part of Pottawatomie county and part of its analysis by Dr. White follows:

"No species in any way characteristic of the Lower Coal Measures or the Allegheny formation remains. On the other hand, the ferns, either as individual species or as phases of species having wide range, are clearly indicative of a stage at least very high in the Upper Carboniferous (Pennsylvanian). Nearly all the species have been reported from either the Permian of Europe or the Dunkard formation of the United States, though, with the possible exception of *Pecopteris Newberriana*, none are distinctly characteristic of the Permian. Most of the forms present occur in the Dunkard formation, whose flora was fully treated by professors Fontaine and I. C. White. * * *

"The evidence presented by this small Onaga flora may, therefore, be construed, so far as it represents the plants of its horizon, as indicating a stage probably within the Monongahela formation of the Appalachian region, or possibly as high as the lowest part of the Dunkard formation, although, with the exception of *Pecopteris Newberriana*, the collection in hand does not contain

† Am. Jour. Sci., 4th ser., vol. xvi, October, 1903, pp. 323, 324.

any species characteristic of the Permian of the old World, and does not signify a Permian age for the Onaga (Elmdale) beds."*

The importance of the above reference to the Dunkard formation will be appreciated when it is recalled that in 1880 professors William M. Fontaine and I. C. White described the flora of the Upper Barren Coal Measures (now called the Dunkard formation) of West Virginia and southwestern Pennsylvania and in conclusion stated that:

"To sum up finally the evidence derived from all sources, we find ourselves irresistibly impelled to the conclusion, that the * * * Upper Barrens of the Appalachian Coal Fields are of Permian age."†

The fauna of the Dunkard formation is very small and does not afford conclusive evidence as to its age but the flora has been recently re-examined by Dr. David White who corroborates the earlier conclusions of Fontaine and I. C. White. In the lower part of the Dunkard formation is the lower Washington limestone, which at the typical locality at Washington in southwestern Pennsylvania occurs 117 feet above the top of the Waynesburg coal or base of the Dunkard. Dr. David White draws the following conclusions regarding the age of the Dunkard formation:

"It appears that the beds below the Lower Washington limestone can not yet be regarded as conclusively referable to the Rothliegende, though they contain a flora which is certainly transitional. The re-enforcement of this flora at the levels of the Washington and Dunkard coals by the more important and distinctly characteristic Rothliegende species * * * seems to fully justify the reference of the latter to the Rothliegende, the lower boundary of which may probably be drawn as low as the Washington limestone, which is as yet the lowest observed Callipteris horizon. Further search in the floras of the lower beds of the Dunkard and in the Monongahela is necessary before the upper boundary of the Coal Measures can be definitely ascertained. The flora of the upper portion of the Dunkard is to be compared with those of the Stockheim and Cusel beds in Germany and of the series in the basin of the Brives in France. * * * The reference of the greater part of the Dunkard to the Lower Rothliegende appears to be well founded; but it seems to the writer as probable that the plants of the Upper Dunkard or of the lowest of the terranes of western Europe that are now generally classed as Rothliegende are hardly of so late a date as the flora of the Artinsk stage of Russia."*

* U. S. Geol. Surv., Bull. No. 211, Nov., 1903, pp. 115-116.
† Second Geol. Surv. Pa., PP., p. 119.
* Bull. Geol. Soc. Amer., vol. 14, March, 1904, pp. 541, 542.

The Rothliegende is the older division of the Permian of western Europe, which is found typically in Germany. The Artinsk stage in Russia is referred by the eminent Russian geologist Dr. Tschernyschew to the Permo-Carboniferous; but by Dr. Frech and many other European geologists it is considered as lower Permian. A number of European geologists have accepted Permian as the age of the Dunkard formation and Dr. Frech states that the Dunkard creek beds and Cassville plant shale, the latter of which is the shale at the base of the Dunkard formation immediately overlying the Waynesburg coal, are the equivalent of the Cusel stage, which is the oldest division of the Lower Rothliegende of Germany. And in another sentence is the statement that the petrographical and paleontological similarity of the Dunkard with the Rothliegende of western Europe is therefore beyond doubt.* Dr. Kayser also puts the Dunkard in the Permian and he has made the following statement concerning its age:

> In the United States we find in the east (Virginia, Pennsylvania, etc.) in conformable layers upon the Upper Carboniferous the so-called Barren Measures with *Callipteris conferta*, *Taeniopteris* and other Permian characteristic forms together with typical Carboniferous plants as representative of the Permian.*

The youngest of the Kansas floras discussed by Dr. David White is that from Dickinson county which he states Dr. Sellards gives

> "As coming either from the topmost beds of the Marion formation or possibly from the base of the Wellington formation."

Dr. White's conclusions are as follows:

> "I have not had an opportunity to examine the remaining material at the State University [of Kansas], but if the composition of the entire flora proves to be of so young a character as the material described or placed in my hands by Mr. Sellards, his conclusion that the beds are of so late date as the Lower Permian will appear to be fully justified. I am not informed whether any of the gymnospermic species so important in, and so typically characteristic of, the Permian of Europe or Prince Edward island are present in Kansas. However, such pteridophytic material as has come to me for examination is more nearly typical and characteristic of the Permian than any flora that I have yet seen from another formation in the United States.

† Lethaea geognostica, Th. i, Lethaea palaeozoica, Bd. 2. Lief. 3, 1901, p. 546.
* Lehrbuch d. geol. Formationskunde, 2d ed., 1902, p. 264.

If the plants preliminarily listed above are representative of the plant life of the Upper Marion or the Wellington formation, the flora of these beds is probably of a date fully as late as the earlier of the floras generally referred to the Permian in western Europe. In any event a flora containing these species can hardly be older than the topmost Carboniferous, or transitional from the Upper Carboniferous to the Permian."*

The last published paper of the late Dr. Charles E. Beecher entitled a "Note on a New Permian Xiphosuran from Kansas" appeared in July, 1904, the horizon of which was given as the Fort Riley limestone (which occurs in the upper half of the Chase stage) and was unhesitatingly correlated with the lower Permian.†

In 1902 the writer stated:

"It is probable, however, that the U. S. Geological Survey will retain the name Permian, but will classify it as the last series of the Carboniferous system."

This is now the official position of the U. S. Geological Survey. The rules of the survey relating to "Nomenclature and Classification for the Geologic Atlas of the United States" were revised during 1902 and 1903 and under the subheading of "Correlation and grouping of sedimentary formations" Rule No. 22 states that:

"The following series are now recognized as applicable to North America; * * * in the Carboniferous, Permian, Pennsylvanian, and Mississippian."*

In numerous recent official reports and papers of the U. S. Geological Survey the upper Paleozoic deposits of the Great Plains are described under the name of the Permian series of the Carboniferous system or period. In fact it now apparently regards the Waynesburg sandstone at the base of the Dunkard formation as of Permian age, since it is so given without question by Mr. Marius R. Campbell in the "Columnar Section" of the Latrobe Folio.* It is also important to note that in nearly all the recent official state and territorial reports, the formations of the general age of those under discussion are described under the name of Permian and classified either as the youngest series of the Carboniferous system or the last system of the Paleozoic.

* U. S. Geol. Surv., Bull. No. 211, p. 117.
† Am. Jour. Sci., 4th ser., vol. xviii, p. 24.
‡ Jour. Geol., vol. x, p. 728.
* Twenty-fourth An. Rept., Director U. S. Geol. Surv., 1903, p. 27.
* Geol. Atlas of the U. S., Folio No. 110, 1904.

This certainly indicates a marked change in the opinions of American geologists concerning the age of these deposits since the publication of the writer's paper on "The Classification of the Upper Paleozoic rocks of Central Kansas" in 1895.†

In 1891 Dr. Th. Tschernyschew, the able Director of the Russian *Comité Géologique* and the eminent authority on the middle and upper Paleozoic of Russia, attended the Washington meeting of the International Geological Congress and later studied the upper Paleozoic rocks of Kansas as exposed along the Kansas river from Manhattan to Fort Riley. In his monograph on "Die obercarbonischen Brachiopoden des Ural und des Timan" he reviews the description and classification of the upper Paleozoic formations of Kansas and correlates them with the Russian. Tschernyschew's conclusions concerning the correlation of the upper Paleozoic deposits of Kansas with those of Russia are as follows:

I have become personally acquainted with the strata of the Wabaunsee and Cottonwood during an excursion in the state of Kansas, the former in the railway cut near the Manhattan station; the latter near the same place in Ulrich's quarry. Both I would prefer to put in line with the Cora horizon in eastern and northern Russia. The Neosho strata, and perhaps also the lower part of the Chase, appear analogous to the Russian Schwagerina horizon and the remainder of the latter, as also the Marion, one must regard as homotaxial to the Russian Permo-Carboniferous and lower Permian. Finally, the Wellington and Cimarron necessarily correspond to the lower red colored Permian in eastern and northern Russia.*

The Schwagerina beds form the upper division of the unquestioned upper Carboniferous of Russia, while the Cora beds form the next older division which is characterized by the Brachiopod shell named *Productus cora*. Succeeding the Schwagerina beds is the Artinsk stage of the Russian Permo-Carboniferous which is classified by Drs. Frech and Kayser and many other European geologists as lower Permian. In my "Classification of the Upper Paleozoic formations of Kansas" published in 1902, but a year before a copy of Dr. Tschernyschew's Memoir was received, the provisional line between the Carboniferous and Permian sys-

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† Jour. Geol., vol. iii, pp. 682-706, and pp. 764-801.

* Mém. Comité Géologique, vol. xvi, No. 2, 1902, pp. 392, 393, of Russian text, and p. 703 of German text.

tems was drawn at the base of the Wreford limestone or lowest formation of the Chase stage. It will be seen that this correlation agrees very closely with that of Dr. Tschernyschew, since he draws the homotaxial line representing the separation of the Russian upper Carboniferous and Permo-Carboniferous either at the base or in the lower part of the Chase stage.

The following table from Dr. Tschernyschew's Memoir gives his idea regarding the correlation of the Russian and American formations:

Ural and Timan of Russia.	Texas and Arkansas	Kansas, Nebraska, Iowa, Missouri
Artinsk—Ablagerungen..	Wichita and Clear Fork beds.	Marion beds. Chase beds.
Schwagerinen—Horizont.	Albany and Cisco beds	Neosho beds.
Cora—Horizont.	Canyon and Strawn beds	Missourian series and Cottonwood beds of Kansas and Nebraska. Wabaunsee beds, Oread limestone and Osage shales of Kansas.*

Several geologists have in a general way correlated the Wichita division of Texas with the lower Permian of Kansas and professor Cummins has stated that:

"It is quite certain that the Ft. Riley horizon is the same as the Wichita division of Texas, and is at the very top of the division."*

Dr. Kayser puts the Wichita in the Permian and has recently written as follows concerning its correlation:

In the southern and western states (Texas, Kansas, Nebraska, &c) occur directly above and in intimate connection with the marine Upper Carboniferous principally sandy, slaty, chalky strata, the so-called Wichita beds. These contain in their lower division numerous Theriodonts (*Naosaurus*), Stegocephs (*Eryops, Cricotus*) and fishes (*Pleuracanthus, Janassa,* etc.) recognized by Cope long since as Permian; in the upper division besides numerous mostly Carboniferous species (especially of the Brachiopods—*Productus, Marginifera, Camarophoria, Spirifera,* etc.—Lamellibranchs, Gastropods) Permian Ammonites (*Medlicottia, Popanoceras, Waagenoceras*). Above, follows as representative of the upper Permian a predomi-

* *Ibid.* p. 395 of Russian and 706 of German text.

* Trans. Texas Acad. Science, vol. ii, 1897, p. 98. For a summary of the various opinions regarding the correlation of the Kansas and Texas beds see Jour. Geol., vol. x, 1902, pp. 724-727.

nant red colored formation composed of sandstones, clays and shales, gypsum and salt-bearing, unfossiliferous, comparable to the Russian Tartarian stage.*

The Tartarian is the upper stage of the Russian Permian and some of the Russian geologists have considered it as of Triassic age. Under the Carboniferous system Dr. Kayser said:

We find in the states of Kansas, Nebraska, Utah, Arizona, Nevada, etc. as in central Russia, an almost exclusively marine, chalky development of the Upper Carboniferous, which gradually passes above into the marine Permian.†

Since the above was written Dr. George H. Girty has published a paper entitled "The relations of some Carboniferous faunas"‡ in which he provisionally correlates the upper Paleozoic formations of Trans-Pecos, Texas with those of Russia and Kansas. In order to understand the nomenclature applied to the geological divisions of this region it is necessary to state that Dr. Girty in 1902 proposed the name Guadalupian for apparently all the Paleozoic deposits succeeding the Pennsylvanian of that region which he stated:

"Shall be employed in a force similar to Mississippian and Pennsylvanian."*

The title of his paper "The Upper Permian in western Texas" indicated the age of the series. This region was studied later by Mr. George B. Richardson who has named the formations and referred the Hueco to the Pennsylvanian series, the Delaware Mountain formation and Capitan limestone to the Permian series to which also the Castile gypsum and Rustler formations are doubtfully referred.*

It is to be remembered in passing that the term "Delaware Mountain formation" is so similar to the Delaware limestone of Orton, a name applied in 1878 to a Devonian formation of Ohio,† that it is not a sufficiently distinctive designation for the Texas formation. In fact it has already been referred to as the Delaware formation which will certainly lead to confusion.

Dr. Girty discusses to some extent Dr. Tschernyschew's

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* Lehrbuch d. geol. Formationskunde, 2d ed., 1902, p. 264.
† *Ibid.*, pp. 205, 206.
‡ Proc. Washington Acad. Sciences, vol. vii, June 20, 1905, pp. 1-26.
* Am. Jour. Sci., 4th ser., vol. xiv, p. 368.
* Univ. Texas Min. Surv., Bull. 9, November, 1904, pp. 32-45.
† Rept. Geol. Surv. Ohio, vol. iii, p. 606.

correlation of American upper Paleozoic deposits with those of Russia and he states that:

"I seem to see in the Texas faunas resemblances to the *Spirifer Marconi*, *Omphalotrochus Whitneyi*, *Productus cora*, and *Schwagerina* zones as their fossils are represented by Tschernyschew. All three of the lower faunas are probably represented by the Hueco formation, while the fauna of the Capitan limestone is in some respects strikingly similar to that of the *Schwagerina* zone."*

Again Girty states that

"It seems probable indeed that all four of Tschernyschew's horizons are represented in the Hueco formation, where the different faunas are not as clearly distinguishable into separate entities as in Russia.†

Girty concludes that

"On the whole, therefore, it seems to me rather more probable that much if not all of the Capitan and Delaware formations is younger than the *Schwagerina* zone."‡

In Tschernyschew's classification the Schwagerina zone is succeeded by the Artinsk stage before the Permian is reached; but it must be remembered that the Artinsk stage is referred to the Permian by a number of other distinguished European geologists.

Finally Dr. Girty makes the following comparison between the Texas and Kansas faunas:

"So far as the significance of the somewhat hastily reviewed evidence has been grasped, it seems to assign the Kansas faunas to about the horizon of the Hueco formation, placing the entire Guadalupian series, or at all events the Capitan, as a younger evolution, whether the two faunas were developed in distinct provinces or the same."*

A comparison of the faunas listed by Dr. Girty from the Hueco formation* with those also listed by him from Kansas† indicates that the faunas of none of the Kansas formations above the top of the Chase stage are related to that of the Hueco. In fact it is a question how much, if any, of the Chase stage should be regarded as homotaxial with the Hueco formation, since part of the species listed from it are generally found in the middle and lower, rather than the upper, Pennsylvanian. With the above suggestion in mind it will be seen that Dr. Girty's correlation between

* Loc. cit., p. 20.
† *Ibid.*, p. 22.
‡ *Ibid.*, p. 23.
* *Ibid.*, p. 26.
* Univ. Texas Min. Surv., Bull. 9, pp. 33-38.
† U. S. Geol. Surv., Bull. 211, pp. 77-83.

the Texan and Kansan formations probably does not differ markedly from that of other geologists and that it leaves the upper Paleozoic deposits of Kansas in the Permian.

The upper Paleozoic fauna of Kansas shows a closer relationship with the Permian of Russia than does that of the Capitan limestone as listed by Dr. Girty, which he provisionally correlates with the Permian of the Salt Range of India, the Carnic Alps and especially of Palermo, Sicily.* Consequently his statement that

"If the Capitan fauna is Permian, then certainly that of Kansas is not,"†

does not follow at all.

My original paper on "The Classification of the upper Paleozoic rocks of central Kansas" was published in 1895.‡ Additional field work and study of the Cottonwood Falls quadrangle rendered it advisable, in compliance with the custom of the United States geological survey to designate each lithologic terrane capable of representation on the topographic map as a formation, to subdivide three of the units which were described as formations in that article. The limits of part of the new formations were clearly indicated in the original paper but, in general, they were not given geographical names. Dr. J. W. Beede was associated with the writer in this later work and during the latter part of December, 1901, Dr. Beede spent some days with him in Columbus. At that time we fully discussed the classification for the formations of the Cottonwood Falls folio, selected the names for the new formations and prepared their preliminary description. The complete list of formation names for the Cottonwood Falls folio was submitted to the U. S. geological survey on March 7, 1902 and included the following six which were listed as "Prosser and Beede, new"; Elmdale formation, Neva limestone, Eskridge shales, Garrison formation, Matfield shales and Doyle shales. The above named terms were considered by the Committee on Geologic Names, March 29, 1902 and according to its chairman, Mr. Bailey Willis they "were recommended for approval without exception." The list was returned to me

* Wash. Acad. Sci., vol. vii, p. 22.
† *Ibid.*, p. 25.
‡ Jour. Geol., vol. iii, p. 682, and p. 764.

stamped as follows: "Approved [signed] C. D. W., Director." The names of the above formations, properly credited, together with descriptions and classification, were first published in the Journal of Geology in December, 1902.*

The statements on pages 54, 55, 56, 57 and 59 of Bulletin No. 211 of the United States geological survey, published the last of October, 1903, in which the authorship of the above mentioned formations is apparently claimed by Mr. George I. Adams, are, to say the least, very erroneous.

In the summer of 1896 the writer spent a few days in southern Kansas in attempting to correlate some of the upper Carboniferous and lower Permian rocks with the more prominent formations of eastern central Kansas. At that time the marked lithologic change in certain formations when followed southward from the Cottonwood Falls quadrangle was not clearly known and as the time permitted only a very hurried reconnaissance the results were not satisfactory. This was especially true regarding the attempted recognition of the Cottonwood limestone, to which the greatest amount of time was devoted. The later researches of Drs. Beede and Sellards, described in the August number of the American Geologist, show, that when followed southward from the Cottonwood Falls quadrangle, the lithology of the Cottonwood limestone and overlying Florena shales changes rapidly so that it is very difficult to determine the limestone's horizon in sections. After the writer's reconnaissance he published a preliminary paper on "The Permian and upper Carboniferous of southern Kansas"* in which a "Section along the Missouri Pacific railroad from Reece to the crest of the Flint Hills† and another "from Grenola to Grand Summit"‡ and at Cambridge§ were described. To the section from Reece to the Flint Hills the writer was able to give but a half day for investigation and from below Grand Summit to Cambridge, only a day. According to Drs. Beede and Sellards, the soil and loose material had been removed from the railroad right

* *Op. cit.*, vol. x. pp. 703-719, and date of publication was *prior* to December 8.

* Kan. Univ. Quart., vol. vi, 1897, pp. 149-175.

† *Ibid.*, pp. 152, 153.

‡ *Ibid.*, pp. 160-162.

§ *Ibid*, pp. 166, 167.

of way in the vicinity of the cuts on the eastern slope of the Flint hills to the west of Reece just previous to their work so that there were "ideal exposures from which to make exact sections." Their detailed studies aided by these excellent exposures showed that the upper part of my section needed correction as they have indicated. At the time of my work the covered slopes misled me regarding the thickness of the strata between the upper cuts so that the total thickness was underestimated and the upper portion of the section correlated incorrectly. No's. 13, 14, and 15 of my section were correlated with the Strong flint,* now known as the Wreford limestone; but Beede and Sellards show that only No. 13 and the lower 15 feet, 8 inches (their measurement) of No. 14 belong in the Wreford limestone, which then has a total thickness in this section of over 27⅔ feet. The remainder of No. 14 represents the Matfield shales with a thickness of from 58½ feet to 62 feet, while No. 15 is the Florence flint with a thickness of from 21½ to perhaps 25 feet. The correction above made also applied to the "section of Wreford limestone near Summit Station" given in the Cottonwood Falls Folio,† where No's. 1, 2 and 3 correspond to No's 13, 14 and 15 of my original section, which has just been corrected. Making similar changes in the Cottonwood Falls Folio, No. 1, with the lower 15⅔ feet of No. 2 becomes the Wreford limestone; the remainder of No. 2 represents the Matfield shales and No. 3 the Florence flint. The statement, farther down the same column of the Cottonwood Falls Folio, that the maximum thickness of the Wreford limestone is shown at this locality should also be corrected because, apparently, only about 28 feet is shown.

As already stated, the writer had but a day for the examination of the section from Grand Summit to Cambridge and did not have another day for the continuation of the section from Cambridge to Burden. For the general stratigraphy of the region he depended on the "Geologic section from Galena to Winfield by Geo. I. Adams,"† on which the lower limestone on the eastern side of the Wal-

* Kan. Univ. Quart., vol. vi, p. 152.
† Geol. Atlas U. S., No. 109, 1904, p. 3, col. 3.
† Univ. Geol. Surv. Kansas, vol. i, 1896, pl. i.

nut river at Winfield, which is the Fort Riley limestone, when followed eastward is apparently represented as outcropping in the lower part of the slope to the west of Cambridge. The detailed investigations of Dr. Beede from Grand Summit to Burden show that the above section is incorrect and that the Wreford limestone occurs at a higher position than the supposed outcrop of the Fort Riley limestone. With this change in the general interpretation of the section it becomes evident, when the strata are followed eastward to the railroad cut east of Grand Summit, that my correlation of the upper limestones there exposed with the Strong, now called Wreford limestone, is erroneous.* Dr. Beede states that the Wreford limestone caps the top of the hills north of Grand Summit and that its base is stratigraphically at least 90 feet above the heavy limestone by the last railroad cut at Grand Summit. This shows that the very fossiliferous shales and shaly limestones, No. 28, of my section, together with the massive limestone below No. 27, do not belong in the Wreford limestone but below the middle of the next older formation, the Garrison. The statement that the fossiliferous shales of No. 28 of the Grand Summit section are equivalent to No. 14 of the section west of Reece is incorrect* as well as that in the Cottonwood Falls Folio, that the lower 25 feet of the Wreford limestone occurs east of Grand Summit station,† which should be omitted.

It is clearly shown by Beede and Sellards in the above mentioned paper that the Wreford limestone is a conspicuous formation which may be readily followed from southern Nebraska across northern and central Kansas, at least into the southern part of the latter state. This is fortunate in case the Wreford limestone be considered the base of the Permian because it will afford a marked lithologic break for the line of division between the Permian and the Carboniferous.

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* Kan. Univ. Quart. vol. vi. 1897, pp. 160, 161, 163, No's. 27 and 28 of the "section from Grenola to Grand Summit."
* p. 163.
† Geol. Atlas, U. S., No. 109, p. 3, col. 3.

THE ATLANTIC HIGHLANDS SECTION OF THE NEW JERSEY CRETACIC.*

By J. K. PRATHER, Waco, Texas.

PLATES VIII, IX and X.

The sections discussed in this paper are located near Atlantic Highlands, Monmouth county, New Jersey, along the line of the Central Railroad of New Jersey from the station at Bay View avenue almost to the next stop at Waterwitch station.

The following beds are found in this section:†

	Cretacic (?) Pleistocene (?)		Columbian formation. Long Branch sand.....	4 ft.
Upper Cretacic	Monmouth....		Red Bank	100 ft.
			Navesink	40 ft.
			Mt. Laurel sand.......	50 ft.
	Upper Matawan	Hazlet sand..	Bay View Avenue sand	35 ft.
			(Upper Hazlet or Wenonah ?)	
			Marshalltown clays....	30 ft.
			Columbus sand	10 ft.

Besides the field relations of these beds their lithological character was subjected to a careful examination. Samples of the beds were taken at intervals as indicated by the letters on the section.

Twenty c. c. of a sample was put in a wash bottle with an equal amount of soda and agitated and allowed to stand for 5 minutes, 1 hour, and 24 hours respectively, and decanted. The 1 hour and 24 hour samples contained little else than fine clay—the character of the other samples is given in a table.

The Long Branch Sand.

A yellow quartz sand not unlike the Redbank but generally has more fine clay material. It is about 4 feet thick and is quite persistent in its occurrence. There is an unconformity between this bed and the Redbank. Above the Long Branch is the Columbian gravel with an uncomformity between it and the Long Branch sand.

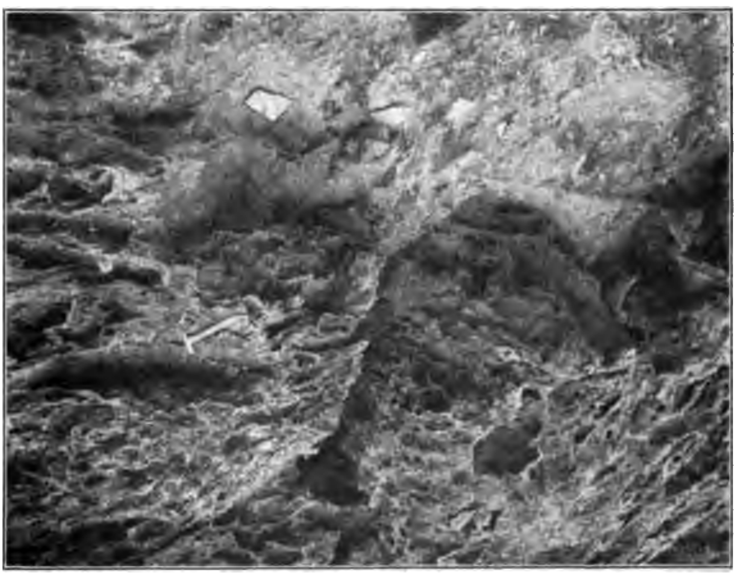
The Long Branch was considered Miocene by Clark, but Weller has found *Terebratula harlani* and *Gryphæa vesicularis* besides Bryozoa and considers it Cretacic.*

* From "The Cretacic Clays at Atlantic Highlands, New Jersey," submitted as an A. M. thesis at Columbia University, April, 1905.

† For a complete classification of the New Jersey Cretacic see paper by Stuart Weller; "The Classification of the Upper Cretaceous Formations and Faunas of New Jersey", Journal of Geology, vol. xii. No. 1.

* See Weller's paper previously referred to (Journal of Geology, vol. xii. No. 1, p. 82.)

Atlantic Highlands as Seen from Raritan Bay.



An Indurated Bed in the Redbank Sand.

Section 800 Feet From Bay View Avenue.

The following table gives characters of beds below the Long Branch.

Bed*	Sample	Residue cc	Residue %	5 minutes cc	5 minutes %	1 hour cc	1 hour %	24 hours cc	24 hours %	Contains.
R	F1	50.10	78.02	9.70	15.10	1.83	2.84	2.60	4.04	Almost entirely quartz grains (uniform size) rounded and triangular, mica flakes, magnetite, orthoclase, microcline, and hornblende.
N	G2	10.00	52.58	6.9	33.01	1.0	4.78	2.00	9.56	Pure glauconite, pyrite, shell fragments, and Foraminifera.
N	G3	14.0	63.00	6.4	28.82	1.6	7.20	0.2	0.90	Mica, 50% rounded grains of quartz, 50% glauconite.
N	A1	6.0	33.33	5.0	27.77	3.0	16.66	4.0	22.22	Largely glauconite, also mica and rounded quartz.
N	B1	14.0	71.06	3.0	15.27	1.5	7.61	1.2	6.09	Same as preceding.
N	Cb	11.1	66.72	3.5	20.83	2.0	11.90	0.2	0.11	No mica, 8% quartz and rest glauconite.
N	E1	12.1	59.02	6.0	29.24	1.8	8.79	0.6	0.29	Largely glauconite with a few quartz grains.
N	Ga	11.1	52.85	9.6	45.71	0.4	0.19	0.86	0.40	No glauconite, largely quartz rounded and triangular, clay and mica.
M	C5	9.0	46.34	6.4	32.98	2.8	14.43	1.2	6.19	Largely quartz with mica flakes.
M	coarse	3.0	15.34	24.0	72.73	1.2	6.21	1.1	5.69	Quartz rounded and angular and of varying size.
M	fine	0.05	0.28	14.00	78.55	3.5	19.66	0.3	1.50	Largely quartz, a little mica, glauconite, pyrite, gypsum, hornblende, serpentine, and fragments of older rocks.
M	D1	3.0	15.87	14.00	74.07	1.5	7.93	0.4	2.11	Fine angular quartz, some mica and glauconite.

* N = Navesink; R = Redbank; M = Matawan.

The Monmouth Formation.

This includes the Redbank, the Navesink, and the Mt. Laurel sand, and was so named by Clark from its typical exposure in Monmouth county.

The Redbank Formation.

The Redbank formation which is about 100 feet thick at Atlantic Highlands is overlaid by the Long Branch beds or in its absence by the Columbian gravels, and rests on the Navesink beds below. It is generally of a bright red color probably due, as Clark states, to the oxidization of the glauconite grains contained in it. The color is not always a deep red and often varies from almost colorless to a vermilion. The colors, yellow, slate, salmon, pink and red are well represented in the samples I have taken. It is a sand and shows by its thickness, distribution and character of its material that it marks an important change in the history of the Cretacic beds of the Atlantic coastal plain.

At the top of the Redbank is an indurated bed called by Weller the "Tinton bed." It is probably represented at Atlantic Highlands by the indurated bed which occurs just beyond Hilton station, and between this point and Waterwitch (see plate). This bed is about 18 feet thick and higher up contains pockets of greensand which still retain the green color, although the surrounding material is red.

Mica flakes are very abundant in the Redbank, and are very characteristic. When the material is colored a deep red there seems to be an absence of glauconite grains, but grains of magnetite are found which might have resulted from an alteration of the glauconite. Some pieces of limonite about the size of one's hand were collected from the Redbank, which must be considered as due to the concentration of the iron derived from the glauconite. Samples examined under the microscope show the Redbank sand to be composed largely of quartz grains of uniform size often cementetd by fine clay colored by iron. Mica, magnetite, orthoclase, microcline, and mornblende are common.

Concretions of limestone are common, both rounded and stalactitic in form.

The Redbank forms a large part of the hills around Atlantic Highlands. Its thickness and color make it an im-

portant and characteristic member of the New Jersey Cretacic.

Both Cook and Clark have included a part of the upper Navesink with the Redbank, but the lithological character of the material of the two formations is so different (one being a quartz sand and the other a clay or glauconite bed) that the line of separation can be traced without much difficulty. The material of these beds was undoubtedly derived from the older rocks to the southeast, as already suggested by Cook.* Clark gives the strike North 50° East with a dip of 25 feet to the mile.

The Navesink Marl.

This was named by Clark from its typical development in the vicinity of the "Highlands of Navesink," Monmouth county, New Jersey. He gives its thickness as 30 to 50 feet with the same dip and strike as the Redbank. This is one of the most important divisions of the New Jersey beds, and besides yielding 300-400 species of invertebrates, it contains more glauconite on the whole than is found in any other of the divisions. It is well exposed at Atlantic Highlands where it varies from 10 to 50 feet in thickness. It is generally of a dark green to light grey color while some layers are so dark as to be called black. These dark layers may be due to a certain amount of vegetable matter mixed with the glauconite. The light grey color comes from weathering and may partly be due to the decomposition of the pyrite contained in the bed. The dark layer which is generally about 10 feet thick may even assume a blue color.

There are three distinct fossil beds in the Navesink which I have called bed 1, bed 2, and bed 3, beginning at the top. The fossils in bed 1 (which is characterized by *Exogyra costata* and *Ostrea larva* are replaced by limonite which, being characteristic, separates these fossils from those of the other two beds. Bed 2 is the *Gryphæa vesicuaris* bed which also contains *Bellemnitella americana*, *Ostrea larva*, *Exogyra costata*, and *Terrabratella plicata*. The fossils in this bed have the parts of the original shells while those of the other beds are chiefly internal molds. There is much clay mixed with the glauconite and the formation on

* Geology of New Jersey. 1868.

the whole is what might be called a clay green sand. Flakes of mica and grains of quartz and feldspar, chiefly orthoclase, but with some microcline, are numerous throughout the bed. Hornblende and pyroxene are also found but they are not so common. The beds weather readily under the influence of the atmospheric agencies and much trouble is experienced by those whose houses are built near the edge of the bluffs on account of the tendency of the material to slide down. In some places where there is a good deal of water percolating over the embankment the material becomes hard and smooth and changes to a black color. The glauconite grains change the color to a brownish yellow, to a black, to a dark blue, to a dark green, or to a pea green, according to the state of decomposition. The beds contain pieces of lignite, and I collected one piece about 5 inches in diameter and about 8 inches long. It was broken out of a steep bank and part of it was left in the bank. Near the top of the Navesink marl is a clay iron stone layer 2 to 4 feet thick, containing numerous glauconite grains. These are held together by the cementing substances of the clay iron stone which is a mixture of limonite and clay. The iron may have been originally a chemical precipitate or it may have come in part from the breaking up of other glauconite grains which had been formed at an earlier period. Bed 1 which is 4 feet to 20 feet thick is a clay containing numerous quartz and feldspar grains and mica flakes, and is characterized by the filling of limonite in the cracks, which are very numerous throughout. The color of the material of this bed is a light grey. Bed 2 is a mass of glauconite grains embedded in a clay of light grey color. This bed is in places made up of a mass of shells. It contains practically no quartz or feldspar grains or mica flakes.

For separation of samples from Navesink see table.

In a sample (G^2 taken from Bed 2 (*Gryphœa vesicularis* bed) there was practically nothing besides glauconite grains and a few shell fragments. Some grains of pyrite were found and some shells of Foraminifera (Nautilus type; Trochoid type; Nucularia type; Nodosaria type) were noted.

In a sample (G^3 taken from bed 3) there is ½ quartz and ½ glauconite. There are well formed crystals of gypsum

in this bed which are of secondary origin. Many samples of the Navesink are made up almost entirely of glauconite grains with only enough fine material to hold them together. The glauconite grains may be only slightly altered but in some instances (sample A[1]) they are changed to a dark brown color, when it takes a good magnifying glass to distinguish them. In this sample mica is found and there are some quartz grains which are larger and more rounded than one would ordinarily expect from the sample. The samples grade from almost pure glauconite to no glauconite grains at all, and mica is generally absent but may be in certain cases abundant. The amount of quartz is variable, ranging from 50% to zero. The feldspar though present only shows in the thin sections as it is too opaque to be told without grinding down the sample.

The Navesink is marked by a fossil bed near its base which bed is very persistent along the whole section, and care should be taken not to confuse these fossils and assign them to the beds underneath as has sometimes been incorrectly done by some of our best workers.

It is to be noted on the whole that in the samples taken much glauconite is found. Besides this many fragments of the older rocks, or land derived material, occur, indicating a near shore deposit. There is much argillaceous material to be found in the samples. The upper part contains more land derived material and mica flakes, and arenaceous material is more common in this part. The principal fossil bed which is designated as bed 3, is the lowest of the three beds which contains the fossils.* It is of varying thickness, generally about 3 feet thick, but often as thick as 10 feet. This lower fossil bed is in some places found where the two beds, bed 1 and bed 2, are missing. It generally contains a considerable amount of indurated material. The color of the Navesink beds is generally darker than those of the Matawan, and they contain more glauconite and less fine material and do not contain the layers and pockets of sand or of clay, which characterize the Matawan formation.

There is an uncomformity between the Navesink and the Redbank showing that erosion has taken place. This

* For a list of species see below.

is indicated by its thinning to the eastward and the absence of the two upper fossil beds which are present in the western part.

The character of the beds renders them easily eroded and the exposures are constantly changing owing to the undermining which is continually going on.

Locally the Redbank alternates with the Navesink due to slipping. At one place the layers can be traced across and a drop of fifty feet is noted.

Fossils from the Navesink.

Owing to atmospheric agencies which cause the higher parts to disintegrate and slide down over the more basal portions, it becomes necessary that the fossils of each bed be carefully collected and studied so as to separate them, for they have been generally intermixed. I have found fossils from a bed at the top of a bluff scattered all the way from the top to the bottom. Both Clark and Whitfield state that the fossils have been collected and labelled in such a way that it is impossible to tell in many instances to what beds they properly belong.

The fossils in the list which follows are from the Navesink, and one of the objects of this paper is the study of this particular bed, ascribing to it the fossils which belong to it, in order to help differentiate the fossils and assign them to the beds to which they properly belong.

In this list the fossils are indicated as follows: very common; common; rare, and very rare: U= given by Whitfield from upper marl; M= given by Whitfield from middle marl.

Gastropods	Other Beds	Navesink	Common	Very Common	Rare	Very Rare
Natica abyssina (Morton)........		Bed 3		×		
Voluntoderma abbotti (Gabb)....	M	"	×			
Turbinopsis elevata (?) (Whitf.).		"			×	
Odontofusus medius (Whitf.)....		"				×
Rostellaria compacta (Whitf.)...		"			×	
Bulla conica (Whitf.)............	U	"			×	
Xenophora lapiferens (Whitf.)...	U	"			×	
Lunatia halli (Gabb)............		" 1 and 3		×		
Calyptraphorus velatus (Conrad).	U	" 3			×	

Gyrodes infracarinata (Gabb)....		"	×			
Odontofusus rostellaroides (Whitf)		"			×	
Trachytriton atlanticum (Whitf.).		"			×	
Modulus lapidosus (?) (Whitf.)..		"			×	
Turritella vertebroides (Morton).		"		×		
Turbinella (?) parva (Gabb)....		"			×	
Trematofusus venustus (Whitf.)..	U	"			×	
Pyropsis perlata (Conrad).......		"	×			
Pyropsis reileyi (Whitf.).........		"	×			
Tudicula plonimarginata (Whitf.)		"	×			
Pyropsis trochiformis Tuomey)..		"	×			
Rostellaria spirata (Whitf.)......		"				×
Pyropsis richardsoni (Tuomey)..		"		×		
Gyrodes altispira (Gabb)........		"	×			
Rostellites angulatus (Whitf.)...		"	×			
Volutomorpha mucronata (Gabb)		"	×			
Volutomorpha conradi (Gabb)....		"	×			
Rostellaria nobilis (Whitf.)......	U	"	×			
Volutoderma ovata (Whitf.)......		"				×
Turritella encrinoides (?) (Morton)		"		×		
Gyrodes obtusivolva (Gabb).....		"		×		
Rostellites nasutus (Gabb).......		"			×	
Volutomorpha ponderosa (Whitf.)		"			×	
Cithara croswickensis (Whitf.)..		"			×	
Pyropsis retifer (?) (Gabb)......		"				×
Pyrifusus turritus (Whitf.)......		"				×
Odontufusus typicus (Whitf.)....		"			×	
Rostellites biconicus (Whitf.)....	U	"				×
Pyropsis corrina (Whitf.).......		"				×
Gyrodes petrosa (Morton)........		"	×			
Trachytriton multivaricosum (?) (Whitf.)		"				×
Rostellaria fusiformis (Whitf.)..		"	×			
Rostellaria curta (Whitf.).......		"				×
Turritella lippincotti (Whitf.)...		"				×
Turbinella (?) verticalis (Whitf.)		"				×
Pyrifusus multicaensis (Whitf.)..		"				×
Anchura compressa (Whitf.).....		"	×			

Palecyopods.	Other Beds	Navesink	Common	Very Common	Rare	Very Rare
Ostrea larva (Lamark)........	U & M	Bed 1, 2 & 3		×		
Idonearca antrosa (Morton)...		"3		×		
Idonearca vulgaris (Morton)..		"		×		
Ostrea glandiformis (Whitf.)...	U	"			×	
Claragella armata (Morton)...		"	×			
Legumen appressum (Conrad)		"	×			
Diceras dactyloids (Whitf.)...		"			×	
Cardium prelongatum (Whitf.)		"		×		
Trigonia mortoni (Whitf.).....		"		×		
Exogyra costata (Say).........		"1, 2 & 3		×		
Veniella conradi (Morton)....		"1 & 3		×		
Dianchora echinata (Morton)..		"2		×		
Neithea quinquecostata (Lamark)		"3			×	
Gryphaea vesicularis (Lamark)		"2 & 3		×		

Veniella subovalis (Conrad)..		" 3			×	
Lucina smockana (Whitf.)....		"				×
Lithodomus ripleyana (Gabb).		"		×		
Arca quindecemradiata (Gabb)	U	"				×
Inoceramus sagensis (Owen)..		"		×		
Nemodon anfaulensis (Gabb).		"				×
Nemodon angulatum (Gabb)..		"				×
Cibota obesa (Whitf.)........		"		×		
Nucula slackiana (Gabb)......		" 1				×
Perrisonata protexta (Conrad)		"		×		
Veniella trigona (Gabb)......		" 3		×		
Liopistha protexta (Conrad)..		" 1 & 3		×		
Arca transversa (Gabb)......		"			×	
Bibota uniopsis (Conrad).....		"				
Inoceramus sagansis var quad-				×		
raus (Whitf.)...........		"				
Inoceramus pro-obliqua (?)			×			
(Whitf.)		2 & 3	×			
Pecten venustus (Morton)....						
Neithea quinquecostata (La-		3	×			
mark)		" 2			×	
Ostrea tecicosta (Gabb).......		" 1			×	
Anonia tellinoides (Morton)...		"				
Inoceramus sagensis var vanux-						
emi		" 3			×	
Crassatella rembea (Whitf.)...	U & M	" 3		×		
Ostrea larva var nasuta (Mor-						
ton)	U & M	" 2		×		
Corbicula species		" 3		×		
Panopea dicisa (Conrad)......		"			×	
Leiopistha inflata (Whitf.)....		"	×			
Pachycardium burlingtonense						
(Whitf.)		"				×
Gnathodon tennidens (Whitf.)		"		×		
Cyprimeria densata (?) (Con-						
rad)		"				×
Cardium multiradiatum (Gabb)		" 1 & 3		×		
Cardium dumosum (Conrad)..		" 3		×		
Cyprimeria spissa (Conrad)..		"			×	
Crassatella littoralis (Conrad).	U	"			×	
Dosinia gabbi (Whitf.)........		"			×	
Crassitella curta (Conrad) (?).	U	"		×		
Leiopistha protexta (Conrad)..		"		×		
Modiola inflata (Whitf.)......	M	"		×		
Exogyra lateralis		" 2			×	
Exogyra costata		"1, 2 & 3		×		
Crassatella vadosa (Morton)...		" 3			×	
Crassatella sp.		" 1				×
Corbicula sp.		" 3				×
Inoceramus sp.		"				×
Neithea quinquecostata (La-		"				
mark		"				×
Veleda tellinoides (?) (Whitf.)		"				×
Donax fordi (Lea)		"				×
Leptosolen biplicata (Conrad)		"				×
Calista delawarensis (Gabb)..		"				×
Cyprimeria excavata (Morton)		"				×
Astarte veta (?) (Conrad)....		" 1			×	
Panopea elliptica (?) (Whitf.).	U	" 3				×
Modiola sp.		"			×	
Cardita britteni (Whitf.)......	U	"			×	

Nuculana species		" 1			×	
Dosinia gabbi (Whitf.).......		" 2		×		
Crassatella alta (Conrad).....	U	" 3	×			
Gryphaea (several species)....		"		×		

Miscellaneous.	Other Beds	Navesink	Common	Very Common	Rare	Very Rare
Crabs claws (described by H. A. Pillsbry ?)...............		Bed 3		×		
Fish vertebræ (large and small)..		"	×			
Fish teeth (various sizes)......		"	×			
Sharks teeth (Cestraciont and squalodonts)		"			×	
Coprolites (different kinds)......		"	×			
Belemnitella americana (Morton)		" 2		×		
Sponges		" 3			×	
Baculites compressus (Say) Morton		" 3		×		
Baculites ovatus (Morton).......		"		×		
Baculites asper (Say)...........		"	×			
Nautilus dekayi (Morton)........		"			×	
Turrilites pauper (Whitf.).......		"				×
Architectonica annosa (Conrad)..	U	"				
Heterococeras conradi (Morton)					×	
Gabb		" 2		×		
Terebratella plicata (Say).......		" 2 & 3				×
Bryozoa		" 3	×			
Serpula cretacea (Conrad) (?)..		"		×		
Plant remains (?)...............		"			×	
Gastrochæna americana (Gabb)..	M	"		×		
Dentalium subarcuatum (Conrad)		"		×		
Dentalium falcatum (Conrad)....		"		×		
Siliquaria pauperata (Whitf.)....		" 1				×
Margaritella abbotti (Gabb).....		" 1				×
Neptunia sp.....................		" 1				×

Mt. Laurel Sand.

Clark gives the Mt. Laurel sand as 5 feet thick at Atlantic Highlands, and includes it with the Navesing and with the Redbank in the Monmouth formation.

At Atlantic Highlands it appears as an oxidized zone beneath the Navesink and is about 5 feet thick. It was traced from Bay View avenue station at Atlantic Highlands in the direction of Hiltons for a distance of 800 feet when it grades into the Marshalltown clay bed and disappears.

Bay View Avenue Lens (2).

This is 5 feet wide and 250 feet in length and seems to be part of the Navesink. It is a dark glauconite (see sample C^b) bed and contains about 8% of quartz grains and the

rest grains of glauconite cemented by clay. No mica flakes noted in this sample. It is a very dark color which may in part be due to the presence of a certain amount of vegetable matter. It lies below the lighter colored green sand of the Navesink (samples C^a and C) and rests above Bay View lens No. 3.

The Matawan Formation.

In the western part of the Atlantic Highlands section the Mt. Laurel sand is underlaid by a quartz sand formation 35 feet thick, which can be traced eastward for 800 feet when it merges into the Marshalltown clay.

The Matawan divisions at Atlantic Highlands are included under Clark's Hazlet sand or Upper Matawan. The divisions are "Bay View Avenue sand," (which I have named provisionally, which represents uppermost Hazlet, and may be Knapp's Wenonah sand). Below this sand, near Bay View avenue, is 30 feet of the dark laminated Marshalltown clay. This latter is 43 feet thick at the eastern end of the section where it has replaced the Bay View Avenue sand. Below this forming the base of the section throughout is the Columbus sand which grades upward into the Marshalltown clay. The Marshalltown clay here is at the top marked by an unconformity.

The Matawan beds at Atlantic Highlands are not very fossiliferous, and besides fragments of a crab's claw there were few fossils obtained from them.

From samples examined with the microscope it was shown that the material composing the beds was largely quartz grains both rounded, flattened, and angular, together with some glauconite grains and mica flakes. Also in some samples hornblende, gypsum, pyrite, serpentine, orthoclase, microcline, pyroxene, etc. were found. There is more or less clay with glauconite grains either disseminated or in pockets. The strike is northeast to southwest—dip 25 feet to the mile as given by Clark.

Following are the detailed characters of the various members of the Matawan series beginning with the highest.

Bay View Avenue Sand.

This is so named from Bay View avenue station near Atlantic Highlands where it occurs. It is from 15 feet to

25 feet in thickness and extends from Bay View avenue in the direction of Hiltons some 800 feet. It is a sand as shown when separated and examined under the miscoscope although it appears at first sight to be a compact clay. It is sometimes found as one bed, or may be made up of a number of small beds or lenses of only local extent varying in thickness from 2 feet to 8 feet (see lenses 4 and 5). The color varies from white to yellow, salmon, brown, orange, and red. It is made up almost entirely of quartz grains with grains of iron, probably magnetite, mica, and some glauconite. The quartz grains are both angular and rounded and are generally of uniform size, although larger and more rounded quartz grains are noted. It rests above the Marshalltown clay and below the Navesink and Mt. Laurel, although the upper Marshalltown clay seems to be about the same age. Sometimes it is coarse like an ordinary sand, and again it is finer grained like a clay. This is probably the upper part of the Hazlet sand of Clark. Part of it may correspond to the Wenonah sand of the New Jersey survey, although on account of local variation it does not seem to fit this so well, and is therefore given a local name.

Bay View Avenue Lenses, (1), (3), (4), *and* (5).

These four lenses are included as part of the Bay View Avenue sand and as part of the Mt. Laurel sand. No. (1) is 4 feet thick and 120 feet long; No. (3) is 4 feet, 5 inches thick and 120 feet long; No. (4) is 2 feet thick and 130 feet long; and No. (5) is 2 feet thick and 70 feet long.

No. (1) is very fine grained and of a light color. It contains quartz and mica but has so much fine clay as to render it a clay rather than a sand, and causes it to break into hard lumps.

No. (3) is much coarser and more arenaceous than No. (1) and contains more glauconite and more quartz and less fine clay. It is a brown color and readily separates into a sand. Nos. (1) and (3) are part of the Mt. Laurel sand.

No. (4) is fine grained like No. (1) but of coarser grain. It breaks up into lumps and has so much fine clay as to make it a clay rather than a sand. It contains quartz and mica but the clay predominates. It is of a light grey color and contains very little glauconite.

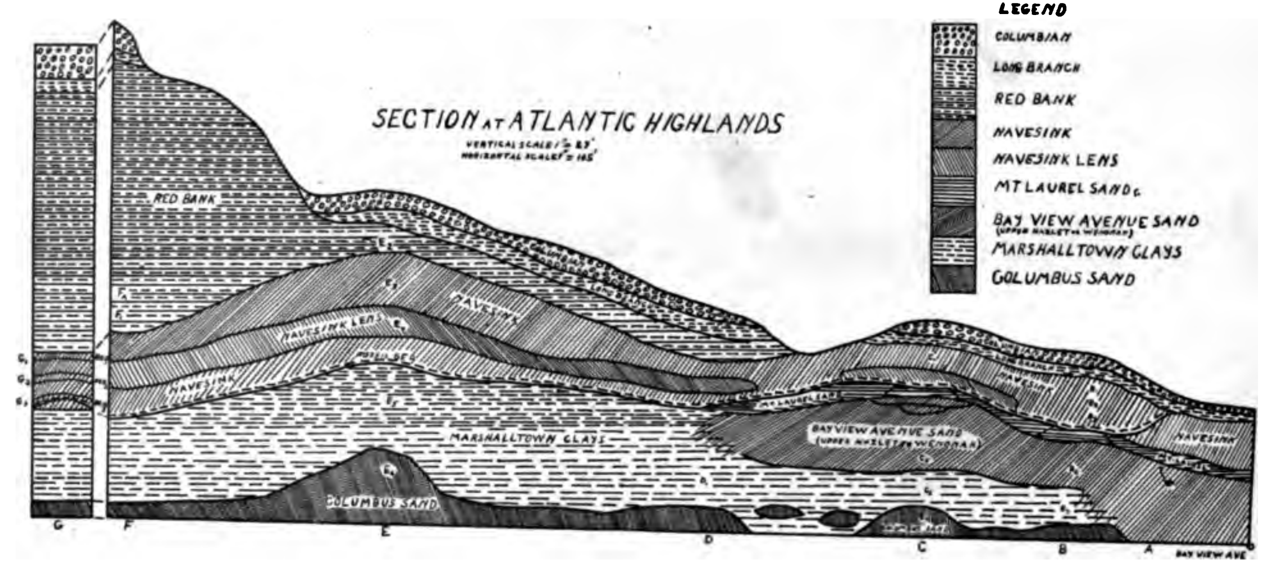
No. (5) is a brown sand but fine grained and containing much fine clay. The grains of quartz and mica are also very small. Nos. (4) and (5) are part of the Bay View Avenue sand.

Marshalltown Clay.

The bed here identified is from 15 feet to 43 feet thick and extends from 200 feet from Bay View avenue to near Hiltons station. It represents part of the Hazlet sand of Clark and would correspond to the (Clay marl 4) Marshalltown bed of Knapp. It is a dark colored clay which varies in color from black to a light grey, when it has a silvery or micaceous appearance. Examined under the microscope it is found to be composed largely of clay and quartz grains, and some mica flakes. It is finer grained, darker in color and very different from the beds, one above, and the other below it, for they are arenaceous (silic arenites) and composed largely of quartz grains, while this bed is more of a clay or clay marl. It might be suitable for making brick or certain grades of earthenware. It is finer grained than the Navesink which rests above it in part of the section, but, in the rest of the section, the bed called Bay View Ave)nue sand comes in between. It contains very little glauconite and is generally very fine grained and contains much fine quartz and mica and a good deal of fine clay.

Columbus Sand.

This generally occurs at the base of the sections from Bay View avenue to near Hiltons. It represents the Upper Hazlet sand of Clark. It seems to be a part of the overlying bed in certain instances and lenses (6) and (7) of this sand are included in the Marshalltown clay above. It varies in color from white to yellow and red, may even assume a slate color owing to the clay present in it. It contains interstratified layers of slate colored clay which is very smooth and fine grained. It is made up largely of quartz grains of variable size, and often highly colored. It contains numerous flakes of mica and many grains of glauconite scattered through it, some of which have been altered to iron compounds. Besides the color, the pieces of clay and the mica flakes are most characteristic. It varies in thickness from 5 feet to 25 feet although on ac-



Section Three Fourths Mile From Bay View Avenue.

count of being at the base, it is not always completely exposed.

SECTIONS.

The following sections taken at intervals give the detail of the formations:

Section 250 feet from Bay View Avenue.

Samples	Material	Thickness	Formation	
	Conglomerate at top	2 ft.	Columbian gravel	
	Sand	3 ft.	Long Branch.	
B1 & B2	Light greensand	10 ft.	Navesink.	
B3	Dark greensand	6 ft.		
B4	Fossil bed with glauconite grains	6 ft.		
B5	Light clay (cream colored) with few glauconite grains (Lens 1)	4 ft.	Mt. Laurel sand.	Upper Matawan or (Hazlet sand)
B6 & Ba	Brown clay containing much quartz grains and mica and with glauconite grains disseminated through it	12 ft.	Bay View Avenue sand.	
B7	Dark clay made up largely of clay and a good many quartz and mica grains	11 ft.	Marshalltown	
	Light gray sand largely quartz with some mica with interstratified layers of clay	6 ft.	Columbus sand.	

Section 450 feet from Bay View Avenue.

Samples.	Material	Thickness	Formation
	Quartz pebbles (conglomerate) at top	2 feet	Columbian
	Quartz sand	5 feet	Long Branch
C1	Light greensand chiefly glauconite. Grains cemented.	7 ft.	Navesink
Cb	Dark greensand most all glauconite. Grains cemented together (Lens 2).	5 ft.	

C2	Brown clay, light brown color and with much quartz (Lens 3).......	4.5 ft.	Mt. Laurel	Upper Matawan or (Hazlet sand)
C3	Brown clay, still lighter color than preceding but composed of same materials (Lens 4)........	2 ft.	Bay View Avenue sand.	
C4	Brownish yellow clay made up largely of quartz grains (Lens 5).......	2 ft.		
C5	Light brown clay with quartz grains and flakes of mica embedded in the clay ground mass..	15 ft.		
C6	Dark grey clay with fine quartz grains	12 ft.	Marshalltown	
C7	Light grey sand largely quartz and some mica with interstratified layers of clay............	8 ft.	Columbus sand.	

Section in bend of Creek 800 feet from Bay View Avenue.

Samples.	Quartz pebbles and sand.........	20 ft.	Columbian 3ft. Long Branch 5 ft. Redbank 12 ft.	
D2	Greensand dark colored and made up largely of glauconite grains cemented and with some grains of quartz and mica scattered through (*)..........	10 ft.	Navesink	
D1	Dark clay made up largely of clay and a good many quartz and mica grains.	35 ft.	Marshalltown	Upper Matawan, or (Hazlet sand)
	Dark gray sand, largely quartz with some mica and interstratified with layers of clay...........	6 ft.	Columbus sand	

* Both the Bay View Avenue sand and the Mt. Laurel sand grade into the Marshalltown clays here and disappear.

Section 1250 feet from Bay View Avenue.

Sample	Description	Thickness	Formation	Group
	Quartz pebbles at top	5 ft.	Columbian gravel	
	Quartz sand	5 ft.	Long Branch	
E2	Quartz sand, salmon colored made up of quartz and some mica and magnetite grains	6 ft.	Redbank	
E3	Light colored clay with quartz and mica in large flakes and some glauconite but glauconite rather rare	20 ft.	Navesink	
E4	Dark green and layers composed of glauconite grains cemented	10 ft.	Navesink	
	Light greens and layers	10 ft.		
E5	Dark grey clay made up largely of clay with much quartz and mica	25 ft.	Marshalltown	Upper Matawan or (Hazlet sand)
E6	Light and dark grey to yellow sand with interstratified layers of clay. The material is largely grains of quartz with large mica flakes and some grains of glauconite	20 ft.	Columbus sand	

Section 1600 feet from Bay View Avenue.

Sample	Description	Thickness	Formation	Group
Samples.	Quartz pebbles	10 ft.	Columbian	
	Sand	5 ft.	Long Branch	
Fa & F1	Red sand changing from dark red to yellow salmon, grey, &c., largely quartz	9.5 ft.	Redbank	
F2	Light green sand	10 ft.	Navesink	
	Dark greens and nearly all glauconite grains cemented together	10 ft.		
	Light green sand	10 ft.		
	Dark green clay made up of quartz and mica grains in clay	25 ft.	Marshalltown	Matawan (Hazlet sand)
	Light colored quartz sand with layers of interstratified clay	5 ft.	Columbus sand	

Section 3960 feet from Bay View Avenue.

Quartz pebbles and sand...............	10 ft.	Columbian
Sand	5 ft.	Long Branch
Red sand largely made up of quartz grains with some hard cemented pieces	90 ft.	Redbank
G1, G2, G3 Glauconite beds with much clay and quartz grains near the top and with less quartz and more glauconite near the middle and bottom, and with numerous fossils, especially in bed 3 or basal portion of bed...........	20 ft.	Navesink

These sections and the intervening parts are shown on the drawing made to scale from measurements and notes taken in the field (Plate x). The sections were drawn to scale on tracing cloth and taken into the field and the beds separately traced out and mapped and the intervals filled in while in the field. The letters A1, B1, &c, refer to samples of the beds, located on the section at the points where they were taken. (See also plates viii and ix).

CONTRIBUTIONS FROM THE MINERALOGICAL LABORATORY OF THE UNIVERSITY OF WISCONSIN.

By WILLIAM HERBERT HOBBS, Madison, Wis., Assisted by others.

PLATE XI.

In the following pages have been brought together a number of brief statements which it is thought are deserving of being placed upon record. Undertaken from time to time as material has come to the laboratory they have been allowed to wait until collectively they had a value which individually would not belong to them. The economical and mineralogical work has been carried out in part by the professor in charge of the department, or by his students, but generally in collaboration. Credit for work is given in connection with the individual contributions.

*a. Analysis of Huebnerite from Dragoon Summit, Ariz.** by S. V. Peppel. The specimens of this mineral are cleavage blades from large hair brown crystals two inches or more in length. An analysis of them yielded the following results:

SiO_2†	1.10
WO_3	75.10
MnO	22.87
FeO	.81
	99.88

The re-calculated analysis excludes the silica, which is probably included material. This analysis appears below in column I, and in column II is given the theoretical composition of pure huebnerite.

	I.	II.
WO_3	76.13	76.6
MnO	23.15	23.4
FeO	.82	
	100.00	100.00

b. Quartz Crystals from near Las Vegas, N. M. These specimens were received from Mrs. A. P. Buck, East Las Vegas, N. M. They constitute numerous double-terminated crystals of clear colorless quartz of great pellucidity resembling in habit the Herkimer quartzes from New York

* This occurrance has been described by W. P. Blake in the Mineral Industry, vol. 7, 1899, pp. 720-722.
† And oxides of columbium group, if present.

state. In common with Herkimer quartzes, also, these crystals are found with much lustrous black material which glows and becomes white on ignition and appears to be in part like the included material of the Herkimer crystals. The crystals sent are somewhat smaller than the average of those obtained from Herkimer county, but they yet resemble them quite closely. These crystals are reported by Mrs. Buck to occur in "veins" in the high country near Las Vegas, hundreds being there found in each shovelful of earth, and the best crystals being obtained in pockets along with the lustrous black material of which, however, only a small amount was included with the sample.

c. Calcite, Sphalerite, and Pyrite from Oshkosh, Wisconsin. The specimens of these minerals were collected from the dolomyte quarry one mile southwest of the city of Oshkosh and presented to the university of Wisconsin by Mr. T. J. Thorson. The calcite shows two habits; one having the form r, ($10\bar{1}1$) unmodified, the other exhibiting the forms f, —2R ($02\bar{2}1$); v, R^3 ($21\bar{3}1$); e, —½R, ($01\bar{1}2$); m, ∞P ($10\bar{1}0$); and r, R ($10\bar{1}1$), the latter form small.

The sphalerite shows the ordinary combination of dodecahedron and trapezohedron (311).

d. Minerals from Eau Claire, Wisconsin. Specimens of pyrite, marcasite, sphalerite, chalcopyrite, and dolomite have been obtained from this locality. The pyrite occurs in well formed octahedral crystals up to ½ centimeter in diameter, with the cube and dodecahedron truncating the angles and edges respectively. The crystals show a greenish to bluish iridescence. Marcasite occurs together with the pyrite and in the common tabular forms which are bounded by the base, unit prism, and one or more of the brachy-domes v. and l. The dolomite occurs in a simple rhombohedron, while the chalcopyrite is found only massive.

e. Dolomite and white Zinc Oxide from Highland, Wisconsin. The dolomite occurs in lenses of small gray and curving faced rhombohedrons with dimensions of a few millimeters only. The specimen of zinc oxide was presented by Mr. Richard Kennedy, mining expert, resident at Highland. This material is quite massive and forms a coat-

ing on the limestone of the district. Its surface is botryoidal and the mineral has the appearance of having been sublimed upon the surface. In color it is almost pure white resembling magnesite; but ignited on charcoal it becomes yellow, cooling to white, and with cobalt solution gives the usual color of zinc compounds. It dissolves readily in hydrochloric acid.

f. Other Unreported Occurrences of Wisconsin Minerals. Other minerals which are not upon record, and which have been found in Wisconsin are given below.

Pyrrhotite from Mountain post office, where it is found in quite extensive deposits entirely massive in appearance.

Barite from Belmont, which occurs with brown blades as imperfect crystals up to 4 or 5 centimeters in length.

Limonite pseudomorphs after marcasite from Madison. These latter pseudomorphs show the combination of the prism m with either v or l.

Malachite; Baraboo, Sauk county.

Chalcopyrite, cuprite, and malachite; Boscobel.

Chalcopyrite, malachite; Soldier's Grove and Wayne.

Graphite; Marshfield.

g. Minerals from Helderberg Limestone of Tiffin, Ohio. The University of Wisconsin is indebted to professor M. E. Kleckner of Heidelberg university located at Tiffin, for a small collection of minerals from the quarries at that place. According to professor Kleckner the limestone of the district is part Niagara and part Helderberg, and it is in the latter that the crystallized minerals have been found. They occur as the lining of cavities some of which have a diameter, as indicated by specimens received, of one to two decimeters. Certain layers in one of the quarries have many filled cavities of cylindrical shape which have become known to the quarry-men as "plugs." These seldom extend through more than a single layer of the limestone. The minerals of this plug are the same as those filling the other cavities; namely, calcite, celestite, fluorite, and sphalerite.

The calcite is the most abundant of the minerals lining the geodes, and occurs in two different habits. The first

shows small yellow crystals ½ centimeter in length with the habit determined by the form f, —2R ($02\bar{2}1$) unmodified. The other type shows larger crystals of "dog tooth" habit which are often several centimeters in length. These crystals like the others are of a pale yellow color and their habit is determined by d, —8R ($08\bar{8}1$) with which is generally present e, —½R ($01\bar{1}2$) and t, ¼R³ ($21\bar{3}4$) and sometimes v, R³ ($21\bar{3}1$). The faces are more or less dull, and frequently vicinal, but allow their angles to be read with sufficient accuracy for a determination of the forms.

The celestite occurs in tabular to bladed crystals varying in size from one-half to several centimeters in their dimensions. The color is a pale blue, as in the case of the well known celestite from Put-in-Bay on lake Erie. The base is always the tabular plane and the macro-diagonal the axis of greatest development. The forms present are, in the order of relative size, c, ∞P (001); d, ½P (112); o, $P\breve{\infty}$ (011); m, ∞P (110); and z, P (111).

The crystals of fluor spar are associated with the calcite and the celestite in the cavities. They are cubes and cubo-octahedrons made up of well-rounded sub-individuals, and sometimes attain to a size of two or more centimeters along the cubic edge. Some crystals are nearly colorless and quite clear; others have areas colored yellow, but the majority of those examined have a rich brown color between that of smoky quartz and of the well-known brown siderites from Roxbury, Connecticut.

A mineral much less common in the geodes is sphalerite, which appears in distinct crystals a centimeter or more in diameter. The color is that of a light "rosin jack" and would match the color of the well known sphalerites from Joplin, Missouri. Like the latter, also, the combination found upon the Tiffin sphalerite is that of the dodecahedron with the common trapezohedron (311).

h. Calcite from Grand Rapids, Michigan. Specimens of calcite from Grand Rapids, Michigan were received from Mr. J. C. Ulman of Ashland, Wisconsin. He collected them in 1894. According to his statement the crystals are found in seams and cavities in the limestone which forms the bed

of the Grand river, coffer dams having been built and the rock quarried both for lime and for road metal. The limestone is traversed by a vertical vein of barite, containing well developed crystals. Two miles down the river the limestone dips under the well known gypsum beds of the vicinity. The rock in which the crystals here described were found, is a dark gray to white compact limestone with cavities which in many of the specimens were lined with a film of pyrite, to which the calcite crystals are attached. These crystals have been studied at the university by Mr. W. M. Kennedy. The habit of the calcite is either scalenohedral or rhombohedral, the latter variety being white and the former when found alone of a brownish-yellow color. Twins are common, the twinning plane being a face of the fundamental rhombohedron. Superimposed upon some of the larger crystals are numerous smaller and much distorted individuals so flattened as to resemble in form the tooth of a shark, the orientation being, however, the same for both larger and smaller crystals. The following forms were observed:

r, R $(10\bar{1}1)$

ϕ, $-\frac{5}{4}$ R $(05\bar{5}4)$

X, $-\frac{9}{4}$ R $(09\bar{9}4)$

𝔡, -3 R $(03\bar{3}1)$

𝔚, $-\frac{11}{3}$ R $(0.\ 11.\ \overline{11}.\ 3)$

ν, R^3 $(21\bar{3}1)$

M, R $\frac{11}{3}$ $(7.\ 4.\ \overline{11}.\ 3)$

𝔥, R $\frac{4}{3}$ $(11.\ 16.\ 5\ 6)$

and

l, $-\frac{11}{3}$ R $(11.\ 0.\ \overline{11}.\ 3)$ doubtful.

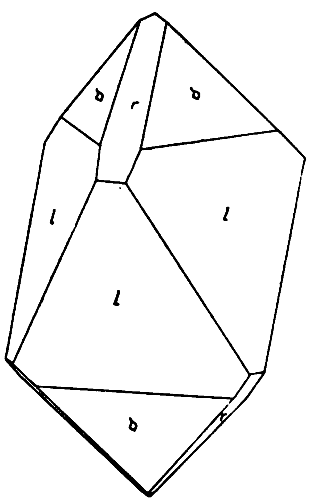


Fig. 1. Development of calcite crystals from Grand Rapids, Michigan. The angles which determined the forms were as follows:

	Obs.	Calc.	Diff.
$\phi\phi'$ (polar)	84°23′	84°32½′	—9½′
$\nu\nu'$	35°33′	35°36′	—3′
$\tau\nu$	29° 5′	29° 2′	+3′
𝔟𝔟′	32°40′	32°36′	+4′
MM′	40° 3′	40° 3′	0
r M	33° 0′	32°57′	+3′
rw	29°52′	29°54′	—2′
r δ	116° 0′	115°57′	+3′
rl	106° 0′	105°59′	+1′

The new form $R\frac{8}{3}$ was found on a number of crystals and was accordingly determined. The form l was found on but one crystal, though here with a large development. See fig. 1.

The crystals represent a number of distinct habits among which is the barrel-shaped type of fig. 2. There is also another "nail-head" type, and a very steep rhombohedral type.

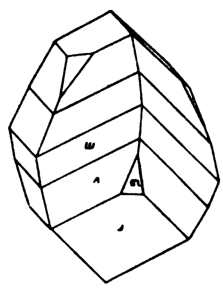


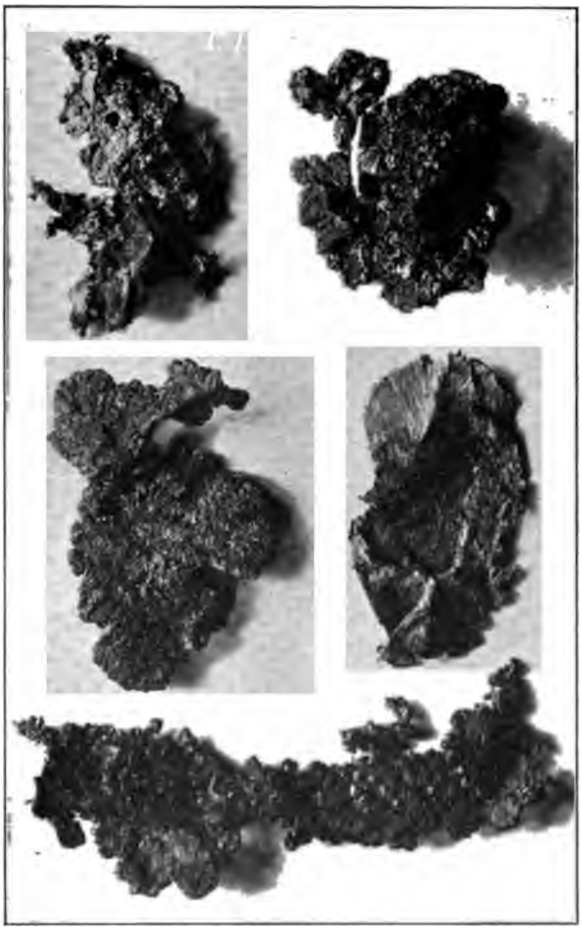
Fig. 2. Barrel-shaped type of calcite from Tiffin, Ohio.

i. Epsomite and Alunogen from the Cripple Creek District, Colorado. These specimens which were among the collections of the university of Wisconsin have been analyzed, the first mentioned by Mr. W. O. Hotchkiss, and the last mentioned by both Mr. Hotchkiss and Mr. R. M. Chapman. Their results follow:

"Epsomite" from Cripple Creek District, Colorado.

Analyzed by W. O. Hotchkiss.

MgO	19.35
SO^3	38.51
H^2O	42.03
	99.89



Metallic Copper, Soudan, Minn

"Alunogen" from Cripple Creek District, Colorado.

Analyzed by W. O. Hotchkiss and R. M. Chapman.

	Hotchkiss.	Chapman.
Al^2O^3	8.28	9.41
MgO	14.44	4.40
SO^3	34.06	43.74
H^2O	43.86	43.86
	100.64	101.41

The close similarity of the two minerals makes it difficult to obtain a perfect separation of them, and this chiefly explains the variation observed between the analysis quoted.

j. Crystallized Copper from Soudan, Minn. A very interesting and almost unique example of metallic copper in association with hematite is the occurrence at the Minnesota mine in the Vermilion iron-bearing district of Minnesota. As this occurrence does not appear to have been figured, the beauty of the films and trees seems to warrant its representation, which is given in plate xi. Although the occurrence has been described,* it does not appear to be well known, the place of publication not being well known to mineralogists. The occurrence is also casually mentioned by Clements.† Together with the hematite in association with the copper are found cuprite, malachite, and azurite. The copper minerals occur, in a narrow seam in brecciated hematite, the only place where it is found in the region or in any of the iron-bearing districts of lake Superior. This rare occurrence should be considered in connection with the discovery by Haworth of thin films of native copper in red clay shales near Enid, Oklahoma.‡ In both occurrences the copper is extremely limited and generally found in thin films upon apparent fissures. Though the Soudan occurrence was apparently not known to Haworth at the time his paper was read, he has suggested the same explanation, namely; the reduction of the copper by the oxidation of the ferrous iron compound.

* J. H. Eby, and Charles P. Berkey. Copper minerals in hematite ore. The Year Book of the Society of Engineers, university of Minnesota, 1897, pp. 108-117. Reprinted from the Proceedings of the Lake Superior Mining Institute, vol. 4, 1896, pp. 69-79.

† J. Morgan Clements. The Vermilion Iron bearing district of Minnesota. Mon. 45, U. S. G. S. 1903, pp. 112, 134. N. H. Winchell *Metallic Copper.* Final report, Minnesota Geological Survey, vol. 5, p. 885, 1900.

It is interesting to note that beautifully crystallized copper has been produced in trees resembling the aborescent native copper of the Soudan occurrence through electrolysis.* This copper was formed at the lower corner of a full sized kathode operating under bad conditions in an insoluble anode tank, presumably with very high current density.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Structure of some Cephalopods, by R. RUEDEMANN. [Report of New York State Paleontologist 1903, Albany, 1905].

Notes on the apical end of the siphuncle in some Canadian Endoceratidae, &c. by J. F. WHITEAVES [American Geologist, Jan. 1905).

Ueber die eocambrische Cephalopodengattung Volborthella, SCHMIDT. von A. KARPINSKY, (Verhandl. russ. miner. Gesell. Bd. xli, li, pp. 31-42].

These papers with that of G. Holm 1895 on the formation of the endosiphon in the Endoceratidæ help greatly to a proper understanding of the initial stage of the shell in the early cephalopods.

Especially is this the case with the first-named essay, based upon excellent material from the oldest Ordovician limestones of lake Champlain. The essay is valuable not only for what it tells us about the Beekmantown cephalopods, but also for the synopsis which it contains of the work of other observers in this field of research—Barrande, Dewitz, Whitfield, Dawson, Hyatt, Holm, Foord, Clarke and others.

Ruedemann's work is based chiefly on the species *Camerocera, brainerdi* Whitfield, and fully describes the delicate chitinous and chitino-calcareous parts of the envelope in this species, which preceded the formation of the calcareous shell. The assumption of the calcareous habit is plainly shown in the individual history of these shells, as it is in several of the Hyolilhidæ of an earlier date. Dr. Ruedemann's work is abundantly illustrated with wood cuts in the text and a series of plates at its close. *C. brainerdi* began in a small cylindrical tube (endosiphotube, page 320) which became differentiated by the addition of an outward enclosing tube (endosiphocoleon). The first named tube fades out or loses its chiten,

† E. HAWORTH Native copper near Enid, Oklahoma, Bull. Geol. Soc. Am., vol. 12, 1901, pp. 2-4.

*LAWRENCE ADDICKS. Electrolytic copper, Electro-chemical and metallurgical industries, vol. 3, 1905, p. 167, fig.

leaving the latter as the endosiphon, Chitenous or sub-chitenous supports (endosiphoblades, &c.) passing to the walls of the siphuncle held this endosiphon in its place.

Gerard Holm has found quite similar structures, though not so complete, in *Vaginoceras basaliforme*. The stage of the single worm-like tube in Cameroceras is rightly regarded by Ruedemann as an important accession to our knowledge of the initial structures in the early cephalopods.

Dr. Whiteaves' paper also has plates, two in number ,which present the characters of two new species of Endoceratites, based on the siphuncle, from Canadian localities, *Nanna primaevus* and *N. kingstonensis*. In the latter which is represented by casts of the siphuncle, the impression of the septal necks is finely shown, and the forward curve of the septal rings is well marked.

A. Karpinsky has made a fresh study of Schmidt's genus Volborthella (*V. tennuis*) from the "blue clay" of the Lower Cambrian of Reval in the Baltic provinces of Russia. He sustains the view of Schmidt that this organism is a cephalopod, since he found it characterized by a siphonal tube. It is a long space in geological time between this organism and the oldest known chambered cephalopod; perhaps the connection between Volborthella and the latter has been through some of the shells classed with the Hyolithidæ to which Volborthella bears a close resemblance. Between the "blue clay" and the Beekmantown horizon four Cambrian faunas intervene—Paradoxides, Olenus, Peltura and Dictyonema—in which no recognized orthoceratites are known. W. U,

The Copper Handbook, a Manual of the Copper Industry of the World. Vol V, for the year 1904. Compiled and published by HORACE J. STEVENS. Pages 882. Houghton, Mich., 1905.

This is the fifth yearly issue of a very comprehensive and useful handbook. It contains chapters on the history, geology, chemistry and mineralogy, metallurgy, and uses of copper; a glossary of mining terms; details of copper deposits in all parts of the world; a very extensive alphabetic list, in 683 pages, describing all the copper mines of the world, and noting all companies engaged in copper production; and statistics, in 38 pages. Concerning the very important and recent uses of this metal for telegraph and telephone wires and a multitude of other electric appliances, the compiler writes: "Copper is the foundation of the Electric Age, just as it was the fundamental metal in the Age of Bronze, some millenniums ago. * * * A full enumeration of the electrical uses of copper would require a volume." W U.

The Honorable Peter White. A Biographical Sketch of the Lake Superior Iron Country. BY RALPH D. WILLIAMS Pages 205; with many portraits and other illustrations. Cleveland, Ohio, 1905.

A very interesting biography of the most prominent promoter of the mining of iron ores in the upper peninsular of Michigan is

here presented, with chapters also on the great iron ranges of Wisconsin and Minnesota. The marvelously large and growing traffic that passes through the Sault Ste. Marie canals, both on the United States and Canadian sides, and the semi-centennial celebration of the opening of the first canal there, are very fully treated. Not only biography and history, but the economic development of the lake Superior region, so far as it has depended on iron ore production, are vividly depicted; and in all the wonderful progress of that region during the past fifty years the subject of this biography was a conspicuous part. W. U.

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CORRESPONDENCE

NOTES ON FOSSILS OBTAINED AT SANKATY HEAD, NANTUCKET IN JULY 1905.—Through the kindness of members of the Nantucket Maria Mitchell Association I was fortunate enough to make a successful collecting trip to the exposure at Sankaty Head in July of the past summer. By the united efforts of the party a section through the fossiliferous beds was laid bare and then worked systematically. The results of the collecting in this manner and also by looking over the loose material were very gratifying. The material thrown out in the previous year's excavating by Mr. J. Howard Wilson was well worked over by the rains of the previous winter and spring. In the small gullies at the base of this material small shells and crab claws were easily seen although very hard to see in the freshly exposed material. As a result of this searching a considerable number of small shells and crab claws were obtained.

One of the finds here was a single specimen of *Scala* ———— ————, making the first specimen of this species known from these deposits. The specimen was excellently preserved. A single specimen of *Scala groenlandica* Perry, was found here many years ago and was noted in the writer's previous list of the Sankaty Head fossils.

Another species of interest was *Cerithiopsis greenii* C. B. Adams, of which but very few specimens have been found at this locality. This specimen was also excellently preserved, showing the protoconch complete.

Among the smaller shells collected were several species of Odostomia. Of these the two species previously reported from Sankaty—*Odostomia impressa* Say and *O. trifida* Gould,—were the most common, the former being represented by at least three times as many specimens as the latter. Besides these two species there were found *O. fusca* C B. Adams, *O. bisuturalis* Say, and *O. seminuda* C. B. Adams. These three species have not previously been reported from Sankaty.

Among other things of interest was the finding of *Arca ponderosa* Say in situ, both valves being together and in the position of life. This species was previously known from this locality by a single valve found by the writer among the material collected by Dr. Scudder. Other pelecypods were found in the lower layer with both valves attached and the shell in the natural position. This tends to show that the shells of this layer at least are in situ and not secondarily deposited.

The crab claws collected included three species. They were identified by Miss M. J. Rathbun as *Callinectes sapidus* Rathbun, *Eupanopeus herbstii* Milne Edwards and *Neopanope texana sayi* Smith. The last was much more common than either of the other species.

In the collection at Nantucket were found two other species of very considerable interest as they were unknown from this locality at the time of publication of the former list (Am. Geol. vol. xxxiv, Sept., 1904). These include a specimen of *Sipho stimpsoni* Mörch, with an excellently preserved protoconch and a large specimen of *Chrysodomus decemcostatus* Say. This latter is a fairly complete specimen, part of the body whorl being broken away, but the spire in good shape.

JOSEPH A. CUSHMAN.

Boston Society of Natural History, September, 1905.

FIELD GEOLOGY IN OHIO STATE UNIVERSITY. **Each spring term an elective course in Field Geology is offered by professor Prosser for advanced undergraduate and graduate students. The purpose of the course is to acquaint the student with the formations as they are seen in the field and to train him in the methods of investigation employed by the working geologist. The course consists of field excursions, laboratory work and study of library references.**

In the field the formations are carefully studied, identified and measured preparatory to making sections and writing detailed descriptions which ultimately take the form of a thesis. In the laboratory, characteristic fossils of the various formations are identified and the literature of the region under investigation carefully studied. Last term fifteen students registered in this course, two of whom were girls, and the latter were as energetic and enthusiastic as the men. The usual equipment for the trips consisted of barometers, hand-levels and staff, tape lines, hammers, chisels, collecting bags and camera. A trip was made each Saturday during the term, with one exception, although the spring was unfavorable for field work on account of the frequent and heavy rainstorms.

Ohio state university is well situated for geological work since every formation of central Ohio is readily reached by one or more of the numerous steam or electric railways radiating from Columbus. Every formation of the state from the Richmond to the Allegheny inclusive was studied in the field save the local and relatively unimportant Hillsboro sandstone. The distance traveled aggregated about 500 miles.

The longest and most interesting trips from the standpoint of stratigraphy and paleontology were to Zanesville in Muskingum county and to Waynesville in Warren county. The latter occupied two days and included trips to the beautiful gorges at Cedarville, Clifton and Yellow Springs. Goe's Station to the south of Yellow Springs was also visited, at this time, where the mottled clays of the Saluda, the Belfast bed and Clinton limestone are excellently shown in a small ravine near the former residence of Mr. Goe. The heavy rains had thoroughly washed all of the small gullies on the hillside and the mottled clays of the Saluda were shown at their best. All of the sub-divisions of the "Niagara" of Ohio, with the exception of the Hillsboro sandstone, were studied at Yellow Springs, Clifton and Cedarville. The Osgood or Niagara shale is best exposed on the bank of Cascade glen at Yellow Springs, while farther up the stream are outcrops of the West Union, Springfield and Cedarville limestones. The gorge of the Little Miami river below Clifton is famous as one of the most picturesque localities in southwestern Ohio, its banks formed by the Springfield and Cedarville limestones. On Massie's creek, however, a little below Cedarville is a vertical cliff which is one of the most interesting places in this region since it shows the contact of the Osgood shale and West Union limestone, the entire thickness of the West Union and its contact with the superjacent Cedarville limestone. In this vicinity is a most clearly marked old channel of the creek, the bed of which is now dry and covered with grass. The Monroe formation, or Waterlime of the Ohio reports, occurs to the west of Columbus and one day was devoted to the study of several of its outcrops which involved a tramp of some twelve miles. The

Devonian limestones and shales are excellently exposed on the Scioto river and its tributaries and the various formations of the Waverly series on the streams to the east of Columbus within a distance of from ten to thirty-five miles. All of these formations were carefully studied using for a guide the recent papers of professor Prosser in which they have been fully described. The youngest Carboniferous formations studied were seen at Zanesville, sixty miles east of Columbus, where the Lower Mercer limestone occurs in the bed of the Muskingum river, and Putnam Hill and the adjacent ones show the succeeding members of the Pottsville and Allegheny formations as high as the Freeport sandstone.

GEORGE F. LAMB.

PERSONAL AND SCIENTIFIC NEWS.

MR. J. E SPURR of the U. S. Geol. Sur. has resigned to accept a position with the Guggenheim Exploration Co. Mr. Spurr has been connected with the survey for ten years and was previously with the Minnesota Geol. and Nat. Hist. Survey. He has written reports on the Mesabi range, the Mercur, Aspen, Monte Christe, Klondyke and Tonopah districts and was to have studied the Goldfield district this year. His work there will be taken up by Mr. F. L. Ransome.

WE ARE GRATIFIED TO LEARN that we have been misinformed in regard to a change in the geological survey of Michigan.—Dr. A. C. Lane is still the able director of that survey. During the present season much active work is going on. Professor Russell is making an examination of the surface geology in the Upper Peninsula, and Mr. Frank Leverett of the United States survey is on the same problem. They are working in cooperation. And at the same time professor C. A. Davis of the university is studying the development and ecology of the peat bog flora. Mr. W. C. Gordon is completing a careful cross section of the copper-bearing formation, to determine the different horizons, near the Wisconsin line. Professor W. M. Gregory is finishing his report on Arenac county. Mr. W. F. Cooper is working on the Wayne county report and watching the shaft going down to rock salt, near Detroit. The state geologist is engaged in detailed studies in the copper region.

SINCE THE RECENT REORGANIZATION of the Louisiana Survey two volumes have been published on the geology of the state, and are known generally as the "Report of 1899"

and the "Report of 1902." In preparing the "Report of 1905" it has seemed advisable owing to the diversity of subject matter, to publish the same in parts and, as usual, style such parts "Bulletins." Bulletin No. 1—Underground Waters of Louisiana; Bulletin No. 2—Magnetic Survey of Louisiana; and Bulletin No. 3—Tide Gage Work in Louisiana, have already been published and may be had gratis by addressing Dr. W. R. Dodson, director Experiment Station, Louisiana, at Baton Rouge, La. For the reports of 1899 and 1902 address "Director Sugar Experiment Sta.," Audubon Park, New Orleans, La.

STUDENTS IN THE INTERCOLLEGIATE summer field course in the geology of the Appalachian region spent the first week in studying the formations of the Coastal Plain of Maryland under the direction of Dr. Clark of Johns Hopkins university and Dr. Miller of Bryn Mawr college. Professors Bibbins of the Woman's college of Baltimore, Cleland of Williams college and Westgate of Ohio Wesleyan university were also members of the party. The boat of the city engineer of Baltimore and the private yacht of the governor of Maryland were generously placed at the disposal of the party which greatly facilitated the work. The second week under the direction of professor Davis of Harvard was spent in central Pennsylvania in studying the Appalachian structure and physiography. Professors Cleland, Westgate, Prosser of Ohio State university and Rice of Wesleyan university of Connecticut participated in this work. The third week was spent studying the formations of central New York, with headquarters at Syracuse, under the direction of professor Hopkins of Syracuse university. From Wednesday to Saturday of this week Section E of the American Association for the Advancement of Science was in session at Syracuse and the following well known geologists participated in some of the excursions: Rice, Prosser, Taylor of Indiana, David White of the U. S. Geol. Sur., Hovey of the American Museum of Natural History, Fairchild of Rochester university, Cushing of Western Reserve and Grabau of Columbia university. The party left Syracuse Saturday with professor Cushing who directetd the study of the pre-Cambrian crystalline and Ordovician formations of the Mohawk valley during the fourth week of the course.

THE AMERICAN GEOLOGIST.
VOL. XXXVI. PLATE I

The portrait of Dr. Herrick, vol XXXVI, plate 1, was badly printed. The binder will please substitute this.

Albert A Wright.

THE AMERICAN GEOLOGIST.
VOL. XXXVI. PLATE III

The portrait of Prof. Wright, Vol. XXXVI, Plate III, was badly printed. The binder will please substitute this.

THE

AMERICAN GEOLOGIST.

VOL. XXXVI. OCTOBER, 1905. No. 4.

TEN YEARS PROGRESS IN THE MAMMALIAN PALÆONTOLOGY OF NORTH AMERICA.*

By PROF. HENRY FAIRFIELD OSBORN, LL. D., D Sc., New York.

Members of the Congress,

I believe that what you as specialists in the many diverse branches of zoology most desire to hear, are the salient results of our recent explorations in America, and their broader bearings on the general principles of zoology.

In 1878, the late professor O. C. Marsh published his notable address entitled: *Introduction and Succession of Vertebrate Life in North America*[2]. Fifteen years later I published a somewhat similar review entitled: *Rise of the Mammalia in North America*[3]. In the ten years which have elapsed exploration has not only been on a larger scale[4] than ever before, but also more thorough as well as guided by the constantly broadening aspects of the science.

The initial plan of the palæozoological survey undertaken by the American Museum was threefold: it was so far as possible to secure not only (1) a complete representation of certain families of mammals, as was done for monographic purposes by Marsh (i.e. Dinocerata, Brontotheriidæ)

* Address of Prof. H. F. Osborn at the International Congress of Zoology, Berne, August, 1904. Reprinted from the Compte-Rendu of the Congress by permission of the secretary.

2 Proc. Amer. Assoc. Adv. Sci., Nashville, 1877, pp. 211-258.

3 Amer. Jour. Sci. 13, xlvi, 1893, pp. 379-392; 448-466.

4 Large collections have been secured by the Museums of Princeton University and the University of California, by the Carnegie Museum Pittsburgh, the Field Columbian Museum, Chicago, and some few additions have been made to the famous collection brought together by professor MARSH at Yale University.

The Department of Vertebrate Palaeontology in the American Museum of Natural History was founded with the present writer as Curator in 1891. Associated with him at various times were the following zoologists and palaeontologists: Messrs. WORTMAN, MATTHEW, EARLE, GIDLEY and BROWN. Fossil mammals brought from the West, secured by exchange, and by purchase, including the entire collection of the late professor Edward D. Cope, now number 9873. The COPE Reptilian and Amphibian Collection is also in the American Museum.

(2), a complete representation of certain contemporary faunas, as was done chiefly by the late professor Edward D. Cope (e. g. the Puerco and John Day faunas), but in addition (3) to secure complete phyletic series of various families of mammals in successive geological horizons from their introduction to their extinction (compare Fig. 2). In each of these features of our plan we have been rewarded with a success far beyond our most sanguine expectations. Our large collections studied by friendly cooperation in connection with those of other institutions, and large collections studied independently in other institutions, notably Princeton and the Carnegie Museum, have naturally brought into a new light some of the important general principles of palæozoology.

I. Progress in the General Principles of Palæozoology.

Palæogeography—The first broader bearing is that of past distribution and palæogeography, in which the accuracy of our records[1] and thoroughness of our search are working a revolution. We are finding the remains of animals which have recently arrived from South America, Asia, Europe[2] and Africa[3], and it would be impossible to narrow the field of American fossil mammalogy even if we desired to do so. The broad study of intercontinental evolution and relations of the mammals is absolutely essential to a philosophical understanding. Those who have followed the rapid recent progress of palæontology know that this spirit of uniting palæontology ever more closely with distribution and palæogeography is that which constantly animates the older as well as many of the younger workers in this field.

Zoological methods—Zoology in the sense of studying extinct forms as living organisms is also becoming closer day by day, and we are now enjoying the recognition by mammalogists (Weber[1], Beddard[2]) of the absolute necessity of coupling the study of ancestral with that of the recent forms in all questions both of distribution and of classifica-

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1 MATTHEW, W. D. *A Provisional Classification af the Freshwater Tertiary of the West.* Bull. Amer. Mus. Nat. Hist., vol. xii, 1899, pp. 19-77.
2 OSBORN, H. F. *Faunal Relatians of Europe and America during the Tertiary Period.* Ann. N. Y. Acad. Sci., vol. xiii, 1900, pp. 46-56.
3 OSBORN, H. F. *Theory of Successive Invasions of an African Fauna into Europe* Ann. N. Y. Acad. Sci., vol. xiii, 1900, pp. 56-58.
1 *Die Saugethiere* 8°, Jena, 1904.
2 *Mammalia.* The Cambridge Natural History, 8°, 1902.

tion. In connection with distribution our chief advance has been to determine the exact geographical location and chronological succession of animals, the local conditions of geological deposition in relation to habits and habitat or environment, as well as its bearing upon the study of past climates, or what may be called palæometeorology.

Adaptive radiation, continental—In connection with the comparison of mammals in their intercontinental as well as in their continental relations, the branching system of Lamarck and the divergence which impressed Darwin is perhaps most clearly expressed by the word "radiation"[3]. Elsewhere the conception of adaptive radiation has been fully developed in connection with the origin of certain orders[4].

It may here be briefly pointed out that Africa[5], South America, North America and Eurasia prove to have been the three chief geographical centres of ordinal radiation.

Adaptive radiation, local.[6]—Quite as important, although not carried on so grand a scale, is the local adaptive radiation which brings about a diversity of type in the same geographical regions and is the basis of the polyphyletic law of which we shall next speak. It is perhaps best illustrated by the Ungulates. In addition to (1) digital reduction (Kowalevsky) and (2) carpal and tarsal displacement (Cope, Osborn) in relation to the choice of harder and softer ground, there is recognized (3) after the primary conversion of semi-unguiculate into ungulate types, a reversed conversion of ungulate types into clawed types, as seen in ***Dichobune*** (Artiodactyla), ***Chalicotherium*** (Perissodactyla), and perhaps in an incipient stage in ***Agriochoerus*** (Artiodactyla); (4) secondary adoption of aquatic habits, as seen, for example, in the Amynodontidæ among the Rhinocerotoidea. Divergence by the above factors has long been recognized. There are also to be seen phyletic series combining in various ways either of the following eight conditions of foot,

3 OSBORN H. F., *Rise of the Mammalia.* Proc. Amer. Association, Adv. Sci., vol. xlii, 1893, p. 215.

4 *Adaptive Radiation of Orders and Families* Ann. N. Y. Acad. Sci. vol. xiii, 1900, pp 49-51.

5 Ann. N. Y. Acad. Sci. xiii, 1900, pp. 56-58.

6 OSBORN, H. F., *The Law of Adaptive Radiation.* Amer. Nat. xxxvi, 1902, pp. 353-363.

skull and tooth structure, which are not found to be necessarily correlated:

Primitive Condition.	Secondary Condition.
(5) Mesaticephaly	(6) Elongation (dolichocephaly) of skull (7) Abbreviation (brachycephaly) of skull
(8) Mesatipody	(9) Elongation (dolichopody) of limbs (10) Abbreviation (brachypody of limbs
(11) Brachyodonty	(12) Elongation (hypsodonty) of teeth

Law of correlation.—The bearing of these observations on Cuvier's law of correlation is to modify rather than to displace it. It may be restated as follows[1]: The feet (correlated chiefly with limb and body structure) and the teeth (correlated chiefly with skull and neck structure) diverge independently in adaptation respectively to securing (feet) and eating (teeth) food under different conditions; each evolves directly for its own mechanical functions or purposes, yet in such a manner that each subserves the other. Thus, for example, there is a frequent correlation between dolichocephaly, dolichopody and hypsodonty, as in certain of the *Equidae;* but there are so many exceptions to such correlation, because of the separate adaptive evolution of each organ, that it would be entirely impossible to predict the structure of the tooth from the structure of the claw, or vice versa.

Law of analogous evolution.—One of the most important advances of the past decade, for which the way was largely prepared, in the previous decade, by Scott's papers on *Oreodon*, *Poebrotherium* and *Mesohippus*, has been the clear recognition of this law. These phenomena give rise to an enormous number of analogies (homoplasies, parallelisms, convergences) not only of structure but of entire types, of families, and of groups, very confusing to the seeker of real phyletic relationship.

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1 Osborn. Amer. Nat. xxxvi, 1902, p. 363.

Evolution in part determinate.—As regards the modes and factors of evolution[2], the continuous stages of evolution which we are securing among the horses, camels, rhinoceroses, and many other families, afford opportunities which have never been afforded before. We are with adaptive characters from their birth or genesis, through their prime, into their decline and death. Through this unique opportunity for observation has been confirmed a view of evolution long shared by most if not all palæontologists, vertebrate and invertebrate, but naturally not understood or

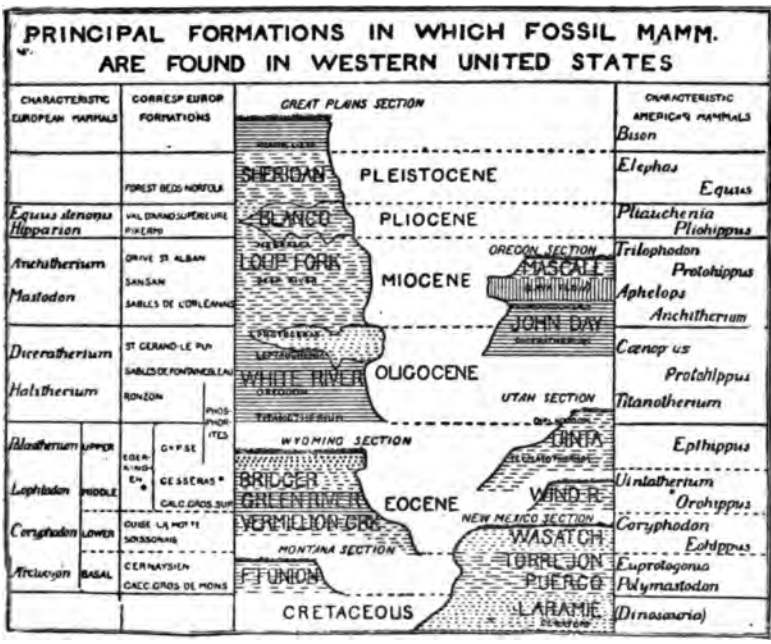

FIG 1.

Most recent geological subdivision of the American Tertiary.

Showing that the successive sections in Montana, New Mexico, Wyoming, Utah, Oregon, and the Great Plains afford a complete history of the Tertiary, homotaxial with that afforded by the corresponding European formations.

shared by other zoologists because of the essentially different nature of evidence. I refer especially to the theory of

2 SCOTT, W. B. *On the Mode of Evolution in the Mammalia and on some of the Factors in the Evolution of the Mammalia.* Jour. Morphol. vol. v, 1891, No. 3, pp. 361-378, 378-402.

the definite or determinate origin[1] and development of certain at least of the new adaptive structures, apparently, but not certainly according to the principle to which Waagen applied the term mutation[2]. The mutation of the palæontologist, however, is quite distinct from the phenomena of minute saltations to which de Vries has applied Waagen's term in his valuable experiments[1].

Potential of similar evolution—In connection with analogous, but especially with partially determinate evolution, we not only have the similarly moulding influences of similar habits, and the action of the various factors of evolution[2] which we cannot stop to discuss, but clear evidence of the existence of a potential of similar evolution, a kind of latent homology which determines that when certain structures are to appear among animals independently derived from a common stock, they will appear at certain definite points and not at random. For example, the genesis of the rudiment of the horn in three independent phyla of Eocene titanotheres is at exactly the same point, namely, at the point of junction of the frontals with the nasals at the side of the face just above the eye.

The polyphyletic law.—Partly as an outgrowth of the synthesis of the above principles and partly as the result of new discoveries and the closer study of types already known is the full recognition of the polyphyletic law.[3] If we examine the phylogenies of Huxley and Cope, and even those of more recent writers (Scott, Osborn, Wortman) of a decade ago, we find that the attempt is made for example, to trace the pedigrees of the horses and rhinoceroses in a monophyletic manner. The first known instance of this kind was Huxley's pedigree of *Equus* through *Hipparion*, *Anchitherium* and *Palaeotherium*, all of which are now known to belong to entirely distinct phyla. Another instance was

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1 OSBORN, H F. *The Palaeontological Evidence for the Transmission of Accquired Characters.* Amer. Naturalist, vol. xxiii, 1889, p. 562.
2 SCOTT, W. B. *On Variations and Mutations.* Amer. Jour. Sci. vol. xlviii, Nov. 1894, pp. 355-374.
1 Elsewhere this profound difference between palaeontological mutations and the mutations of de Vries is carefully pointed out. See "OSBORN Present Problems of Palaeontology", address before St. Louis Congress of Science and Art, September, 1904, first printed in Popular Science Monthly, December, 1904.
2 OSBORN, H F. St. Louis Address. *Loc. cit. supra.*
3 OSBORN, H. F. *The Perissodactyls typically, polyphyletic*, Science, N. S., vol. xvi, 1902, p. 715.

the comparatively recent effort to trace all rhinoceroses through the Oligocene ***Aceratherium occidentale*** Leidy as the stem form.

The polyphyletic law is an outgrowth of four different kinds of evidence. First, that the stem forms are very much older than we supposed them to be; we placed them in the Pliocene and Miocene, they have now been traced to the Oligocene and Eocene. Second, as a consequence of this, certain modern genera of mammals have their own ancestry, apart from that of closely related genera, as far back as the Oligocene and perhaps Eocene. The most conspicuaus example of this is the tracing back of the Dholes (genus *Cyon*) among the Canidæ, to an Oligocene form, showing that Cyon separated from *Canis* in the Eocene (Wortman and Matthew)[1]. Third the polyphyletic law is the result of local adaptive radiation or divergence apparently of habit either by choice or by necessity. For example, among the horses it separates off the grazing types (*Protohippus*), which are naturally progressive, from the browsing types (*Hypohippus*), which are naturally conservative, both found in the same locality (Fig. 4). It thus splits up animals living in a single region into a number of contemporaneous types or genera which may coexist throughout long periods: it is a *segregation*, functional rather than adaptive. Fourth, the polyphyletic law results from the invasion into a region of a generic or specific phylum which has evolved on another continent: for example, the Eurasiatic *Teleocera* came in among the American rhinoceroses in the Middle Miocene.

This polyphyletic law has now been demonstrated (Osborn[2]) among the rhinoceroses both of Eurasia and of North America, and is the key to the comprehension of this group; in Fig. 3 printed herewith it is shown that there are not only three families, namely, cursorial (Hyracodontidæ), aquatic (Amynodontidæ), and terrestrial (Rhinocerotidæ), but that the last family splits up into six and possibly seven phyla, many of which are contemporaneous; and the ten-

1 *The Ancestry of Certain Members of the Canidae, the Viverridae, and Procyonidae* Bull. Amer. Mus. Nat. Hist., vol. xii, 1899, pp. 139-148.
2 *Phylogeny of the Rhinoceroses of Europe.* Bull. Amer. Mus. Nat. Hist., vol. xiii, 1900, pp. 229-267.

dency of discovery will be to increase rather than to diminish the number of contemporaneous independent phyla. Similarly the Eocene titanotheres instead of forming a successive monophyletic series, divide into four distinct phyla, to each of which a generic name must be given. Similarly again, the lower Oligocene titanotheres[4], as shown in Fig. 7, divide into four phyla, three of which have been traced in successive stages from the bottom to the summit of the Oligocene, each giving off several collaterals, all living in the same region and found in contiguous beds, but probably having a slightly different local habitat and habits. The law is illustrated again, as shown in Fig. 4, both in the Oligocene and Miocene horses; in the Oligocene, for example, we have five contemporaneous lines of horses (Osborn[5], Gidley), one of which includes the classic ***Mesohippus bairdi*** of Leidy, which was long considered the single Oligocene horse, and figured as such in all phylogenies; in the Upper Miocene beside the ***Protohippus*** which still apparently is most nearly ancestral to Equus, we find as contemporaries, the browsing, forest-living *Hypohippus* and the grazing and highly cursorial *Neohipparian*, A comparison of the phylogeny of the Camelidæ (Fig. 5) published by Wortman[1] in 1898 on the monophyletic basis with that published by Matthew[2] in 1904 on the polyphyletic basis, shows the rapid progress which has been made in the demonstration of the polyphyletic law. Similar results are apparent from our preliminary studies of the Proboscidiae in America. Many able contemporary workers, especially Schlosser and Deperet, are also bringing forth new illustrations of this law in Europe.

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3 *New Miocene Rhinoceroses with Revision of Known Species.* Bull. Amer. Mus. Nat. Hist., vol. xx, 1904, pp. 307-326.

4 *The Four Phyla of Oligocene Titanotheres.* Bull. Amer. Mus. Nat. Hist., vol. xvi, Feb. 1902, pp. 91-109.

5 *New Oligocene Horses.* Bull. Amer. Mus. Nat. Hist., vol. xx, May, 1904, pp. 167-179.

1 *The Extinct Camellidae.* Bull. Amer. Mus. Nat. Hist., vol. x, 1898, pp. 93-142.

2 *Notice of two New Oligocene Camels.* Bull. Amer. Mus. Nat. Hist., vol. xx, 1904, pp. 211-215.

Modern Fauna, Higher Placental Radiation.
Archaic Fauna, Lower Placental Radiation.

FIG. 2.

Extinction of the lower placental radiation of the Cretaceous, and sudden Introduction of the higher placental radiation of the Tertiary.

The orders Amblypoda, Condylarthra, Edentata, Creodonta, and earlier Primates disappear in North America. The comparatively modern Rodentia, Carnivora, Perissodactyla, Artiodactyla, and Proboscidea suddenly appear without known ancestors in the Lower Tertiary. No connections have thus far been traced between this older, archaic fauna and the newer fauna.

II. Progress of Discovery and the New Phylogenetic Problems Suggested Thereby.

My purpose in this section is to give a brief resumé of the progress during the past ten years, and in our present state of knowledge to point out where exploration and research should principally be directed.

The general advance has been made in five distinct lines, which appear to mark out also the main lines for future research. First, the biological value of more accurate geological records (Compare Fig. 1), has been recognized; as a result the mammalia have been chronologically segre-

gated into successive life zones similar to those which have long been developed in invertebrate, palæontology; these life zones in some cases subdivide not only the periods (Eocene, Miocene, etc.), but also subdivide the stages (Bridger, Unita), etc. Second, not only have these clearer chronological subdivisions been made, but the faunas have been separated according to their kinds and the nature of the deposits, into those which inhabited respectively the lowlands and rivers, forests, plains, and uplands. The advance of physiography has been felt, and by the careful work of Hatcher[1], Matthew[2], and Gidley[3], the theory of fluviatile, flood plain, and æolian deposits has tended to replace the theory of great lakes or lacustrine deposits. Third, there has accordingly been brought about a modification of our views as to the meteorological or climatic phases of the Tertiary period, in the direction of extending the idea of the existence of great dry plains with drifting sands favorable to Aeolian deposits chiefly in the Lower Pleistocene, Pliocene and Miocene; we speak less of a moist, subtropical, and more of a drier climate. Fourth, the zoogeographical relations of the North American faunas to those of other continents have become much more clearly understood (Osborn[6]) in connection with more exact geological records not only by the addition of many new forms ffom the Eurasiatic radiation hitherto unknown, but also by observing more precisely the time of arrival of Eurasiatic migrants in the Lower, Mid- and Upper Miocene and of South American in the Pleiocene. Fifth, the phylogenetic succession has become much clearer and more direct, although a vast amount remains to be done. The separate branches of the mammalian phyletic tree have been successfully traced back farther and farther toward the beginnings of the Tertiary,

1 *Origin of the Oligocene and Miocene Deposits of the Great Plains* Proc. Amer. Philos. Soc., xli, No. 169, Apr. 1902.

2 *Is the White River Tertiary an Aeolian Formation* Amer. Nat., xxxiii, May, 1899, pp. 403-408.

3 *Fossil Mammals of the Tertiary of Northeastern Colorado,* Mem. Amer. Mus. Nat. Hist., vol. 1, pt. vii, Nov. 1901.

4 *The Freshwater Tertiary of Northwestern Texas.* Bull. Amer. Mus. Nat. Hist., vol. xix, 1903, pp. 617-635.

5 MATTHEW and GIDLEY. *New or Little Known Mammals from the Miocene of South Dakota.* Bull. Amer. Mus. Nat. Hist., vol. xx, pp. 241-265.

6 *Faunal Relations of Europe and America. Science,* vol. xi, April, 1900, pp. 161-514.

with resultant changes in our classification. Perhaps the most signal taxonomic result of this phylogenetic progress is in the clear definition of certain genera, notably among the rhinoceroses (Osborn[1], Thomas[2]), as shown in Fig. 3; it has proved to be absolutely necessary for the sake of clearness to recognize a number of genera which many systematists (Flower, Lydekker) have considered simply synonyms of the genus ***Rhinoceros.*** Sixth, the chief morphological result is the discrimination of sexual characters, especially among the male and female forms[3], which in many cases by Marsh and Cope had been considered as distinct species. The recognition (Osborn[4]) that progressive dolichocephaly and brachycephaly profoundly modify all the characters of the skull and the teeth on the principle of correlation, also represents a morphological advance.

The independent and more or less cooperative field or museum work of SCOTT, OSBORN, WORTMAN, MATTHEW, HATCHER, DOUGLASS, GIDLEY, PETERSON, has been instrumental in fordwarding these chief lines of progress.

THE OLDER MESOZOIC FAUNA.

Unfortunately the efforts of the American Museum to find more of the Protodonta (*Dromotherium, Microconodon*) from the Upper Trias or Rhætic have proved unavaliing. The relation of these animals to the Theriodont reptiles has been suggested (Seeley), but the single bone of the jaw rather sustains their relation to the mammalia. The groove on the inner side of the jaw of all Mesozoic and some recent mammals is now recognized as the Meckelian-cartilage groove (Bensley[5]).

In the Upper Jurassic or Lower Cretaceous mammalia of the Como beds we must also admit that no progress has been made to determine whether these animals represent both Insectivora and Marsupialia and perhaps Monotremata (Osborn), or whether they are all Marsupialia[1] (most Eng-

1 *Phylogeny of the Rhinoceroses of Europe.* Bull. Amer. Mus. Nat. Hist., vol. xiii, 1900, pp. 229-267.
2 *Notes on the Type Specimen of Rhinoceros lasiotis Sclater with Remarks on the Generic Position of the Living Species of Rhinoceros.* Proc. Zool. Soc., Lond., June 4, 1901, pp. 154-158.
3 *The Cranial Evolution of Titanotherium.* Bull. Amer. Mus. Nat. Hist., vol. viii, 1896, pp. 157-197.
4 *Dolichocephaly and brachycephaly in the Lower Mammals.* Bull. Amer. Mus. Nat Hist., vol. xvi, 1902, pp. 77-89.
5 *On the Identification of Meckelian and Mylohyoid Grooves.* Univ. of Toronto Studies Biol., Ser. 3, 1902, pp. 75-81.

lish authors). A re-study (Osborn[2]) of the structure of the upper molars in the Yale Museum collection strengthens the tritubercular theory (Cope, Osborn) of the origin of the upper molar teeth.

THE UPPER CRETACEOUS FAUNA.

Here again the relatively modernized (Osborn[3]) animals of the Upper Cretaceous or Laramie, although carefully revised, still require elucidation from the rich collection in the Yale University Museum. Marsh's statement that certain of these animals are Marsupials has been fully confirmed by Matthew, a fact which is striking in the absence of any present evidence of Marsupials in the American basal Eocene.

The present relations of these Laramie animals to those of the Basal Eocene (Puerco, Torrejon has been somewhat strengthened by the recognition of the ancestors (***Meniscoessus***) of *Polymastodon* also by the supposed recognition of forms related to the Amblypoda, especially to the Periptychidæ (Osborn); but forms certainly ancestral to the Creodonta and other Eocene mammals have not yet been recognized.

THE BASAL EOCENE FAUNA.

In this fauna, commonly known as Puerco, great progress has been made.

Two sharply defined faunal stages have been distinguished (Wortman), a lower, Puerco proper, and an upper, Torrejon (Matthew[4]), (Compare Fig. 1, 2). The latter is more nearly contemporaneous with the Basal Eocene (Cernaysien) of France. Fortunately, in Montana, a new locality has been discovered for these very archaic mammals in the Fort Union beds (Douglass[5], Farr) which promises to extend our knowledge of this fauna.

The zoogeographical relations of this fauna, already established by some parallels with the Cernaysien of

1 AMEGHINO, Fl. *Los Diprotodontes del orden de los Plagiaulacideos.* An. Mus. Nac., Buenos-Aires, t. ix, 1903, pp. 81-192.

2 *Palaeontological Evidence for the Original Tritubercular Theory.* Amer. Jour. Sci., vol. xvii, April, 1904, pp. 321-323.

3 *Fossil Mammals of the Upper Cretaceous.* Bull. Amer. Mus. Nat. Hist., vol. v, 1893, pp. 311, 339.

4 MATTHEW. *A Revision of the Puerco Fauna.* Bull. Amer. Mus. Nat., Hist. vol. ix, 1897, pp. 260-261.

5 *A Cretaceous and Lower Tertiary Section in South Central Montana* Proc. Amer. Phil. Soc., vol. xli, 1902, No. 170, pp. 207-224.

France, have been perhaps extended by discovery of the Notostylops beds in Patagonia (Ameghino[1]). Faunal unity with the extremity of South America if confirmed will be of great significance; it appears to be probable but perhaps not absolutely demonstrated.

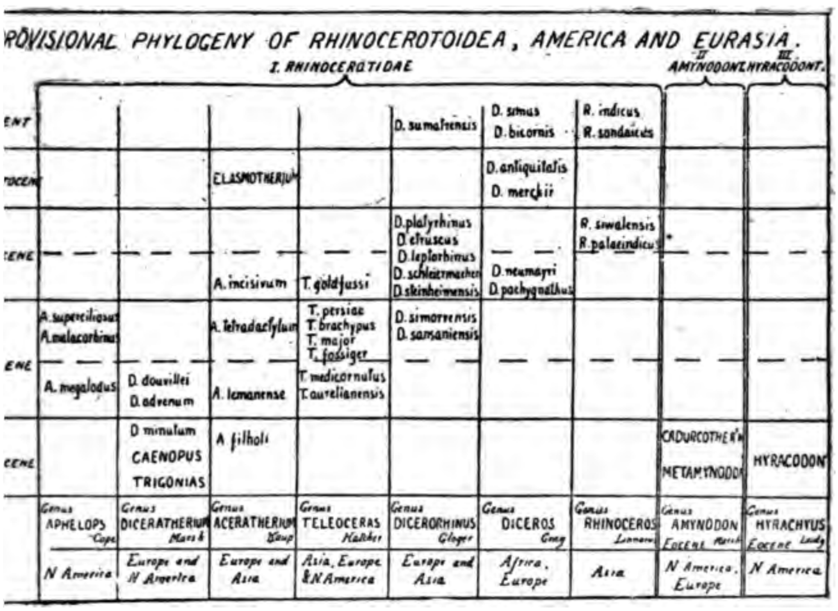

FIG 3.

The Polyphyletic Law Illustrated in the Rhinoceroses.

The Rhinocerotoidea early divided into the *Hyracodontidae* (iii), known only in America, Amynodontidae (ii), known in America and Europe, and the *Rhinocerotidae* (i) The last family of true rhinoceroses prove to include at least seven distinct phyla corresponding to seven genera which extend back as far as the Middle Miocene if not into the Oligocene.

The most important single phylogenetic result is the strong evidence which has been brought forward for the ancestral relationship of the Tæniodonta (Ganodonta) of the Torrejon to the Gravigrade Edentata (Wortman[2]), borne out by careful comparison of many parts of the skeletons of Psittacotherium and allied forms with those of the gravigrade sloths. Indirect proof of the early existence of

1 *Quadro Sinoptico de las formaciones terciarias y cretaces de la Argentina.* An. Mus. Nac. d. Buenos-Aires, t. viii, Julio, 1902.
2 *The Ganodonta and their Relationship to the Edentata* Bull. Amer. Mus. Nat. Hist., vol. ix, 1897, pp. 59-110.

Edentates in North America has come to hand in the discovery of Dasypoda in the Middle Eocene (Osborn[1]).

Another observation which may prove to have very broad phylogenetic bearings is the evidence of arboreal ancestry in the structure of the feet of the Creodonta, Condylarthra and Amblypoda (Matthew); it has not yet been ascertained whether this evidence is of the same nature as that which exists in the feet of the Marsipials (Huxley, Dollo, Bensley). With this exception attempts to bring these essentially archaic Placentals nearer to the Marsupials have not been successful.[2] The single direct link with the higher Placentals which has even been alleged to occur in these beds is the supposed ***Viverravus*** of the Torrejon. The opinion has therefore been expressed (Osborn[3]) that these animals should be sharply separated from the higher placentals and placed in the Meseutheria.

Among the unsolved problems in this Basal Eocene fauna is also its source, or ancestry, which has only in part been traced into the Cretaceous fauna. We require fuller evidence as to the relationship with the ***Notostylops*** fauna of Patagonia (Ameghino), also a positive demonstration that the Tæniodonta are really ancestral to the Edentata. In other words, the phylogenetic connections of these Basal Eocene Placentals of North America and Europe are circumscribed; the sanguine view of Cope that they contain the sources of the modern Placentals which first appear in the Lower Eocene has not been realized; none of these animals give us the stem forms of the true Carnivores, Perissodactyls or Artiodactyls of the Lower and Middle Eocene.

LOWER, MIDDLE AND UPPER EOCENE FAUNAS

The chief geological and faunal progress has been in the Bridger (Bartonien) and Uinta (Ligurien) stages, corresponding to the Middle and Upper Eocene, which have at last been clearly and sharply divided into two successive faunal stages for the Bridger (Matthew, Granger), and two successive faunal stages for the Uinta (Peterson, Osborn). The importance of these divisions in the evolution of the

1 *An Armadillo from the Middle Eocene (Bridger) of North American* Bull. Amer. Mus. Nat. Hist., vol. xx, 1904, pp. 163-165.
2 WORTMAN. *Studies of Eocene Mammalia in the Marsh Collection.* Part I. Carnivora. Amer. Jour. Sci., vols. xi-xiv, 1901, 1902.
3 *A Division of the Eutherian Mammals.* Trans. N. Y. Acad. Sci., June 4, 1894, p. 234.

Primates, Carnivores and Perissodactyls can hardly be overestimated.

At the same time the zoogeographical relationships of our Lower Eocene (Soissonien) have been extended by the discovery of a French Creodont (*Palæonictis*) in America and of an American Creodont (*Pachyaena*) in France. Still more surprising and important is the discovery[1] in the Middle Eocene of Dasypoda (*Metacheiromys*), armadillos with canine teeth and with provision for a stout leathery if not osseous carapace. This absolutely establishes the Cretaceous if not Basal Eocene zoogeographical relations of North and South America, and adds another fact to the growing evidence that North and South America were related in the Mid-Cretaceous and perhaps Early Tertiary and then separated again until the Pliocene.

Our phylogenetic results have been mose encouraging in some directions and most baffling in others. Still more striking than ever before is the fact that the Lower and Middle Eocene fauna of Perissodactyla, Artiodactyla, Carnivora, Cheiroptera, Monkeys, and true Rodents, an essentially modern fauna, is without any known direct affiliation with the Basal Eocene fauna (Meseutheria) (Compare Fig. 2). Mingled with this essentially modern fauna are the numerous survivors of the archaic fauna, namely, the Creodonta, Condylarthra, Amblypoda, with which should certainly be reckoned the Edentata (Paratheria, Thomas) and probably the Insectivora.

The phylogenetic successions of the families within these archaic orders have been much more clearly traced, namely, the pedigree and adaptive radiation of the Creodonts into specializations of various kinds[2]. Among the Amblypoda the law of long-skulled and short-skulled phyla has again been found to prevail, in proof that the genera about which there was such a heated discussion, namely, *Tinoceros* as a relatively short-skulled form and *Loxolophodon* as a relatively long-skulled form, really represent two valid and distinct phyla.

1 Osborn, H. F. *An Armadillo from the Middle Eocene (Bridger) of North America*. Bull. Amer. Mus. Nat. Hist., vol. xx, 1904, pp. 163-165.
2 Matthew, W. D. *Additional Observations on the Creodonta* Bull. Amer. Mus. Nat. Hist., vol. xiv, 1901, pp. 1-38.

Among the modernized Placentals, we have added nothing to our knowledge of the supposed Cheiroptera. An important step is the proposed transfer to the Insectivora of the genus *Hyopsodus* which has long figured among the Primates (Wortman[3]), a relationship which will be settled by material now in our possession. Among the remaining undoubted Primates (Osborn[4]) there is the series of Anaptomorphidæ which still resemble the Tarsiidæ more than any of the other lemurs, or true monkeys, although their actual relationships are absolutely undetermined. The second family of Primates, represented by the Notharctidæ (*Notharctus* and *Limnotherium*) and other forms, has been placed near the South American Cebidæ by Wortman[1], but this also requires the confirmation or disproof which will soon be forthcoming; if South American relationships are established for these Primates, a very much mooted problem will be solved.

Among the Perissodactyla the Titanotheres (Osborn[2]) have split up into four phyla, one of which (*Palaeosyops*) died out, while the three remaining phyla independently acquired rudimentary horns (*Telmatotherium*, *Manteoceras* *Dolichorhinus*) and apparently gave rise to the evolution of the four phyla of great Oligocene titanotheres. Among the Artiodactyla the rare Middle Eocene forms still require elucidation, but the Camelidæ have been traced definitely into the diminutive Upper Eocene (Uinta) *Protylopus* (Scott[1], Wortman[2]). Two distinct phyla of Oreodontidæ have also been traced back in the Upper Eocene into the genera *Protagrichoerus* and *Protoreodon* (Scott). Among the enemies of these animals, the Canidæ have been traced into the Upper Eocene genera *Prodaphaenus* and *Uintacyon* and Marsh's Middle Eocene *Vulpavus* has also proved to be a member of the true Canidæ, although, its relationships

3 *Studies of Eocene Mammalia.* Part II, Amer. Jour. Sci., vol. xv, May, 1903, p. 401.
4 *American Eocene Primates*, etc. Bull. Amer. Mus. Nat. Hist., vol. xvi, 1902, pp. 169-214.
1 WORTMAN. *Op. Cit.*, Amer. Jour. Sc., vol. xv, 1903, pp. 409-411.
2 *The Four Phyla of Oligocene Titanotheres.* Bull. Amer. Mus. Nat. Hist., vol. xvi, 1902, pp. 91-109.
1 *The Selenodont Artiodactyls of the Uinta Eocene.* Trans. Wagner Free Inst. Sci. Phil., vi, 1899, p. 100.

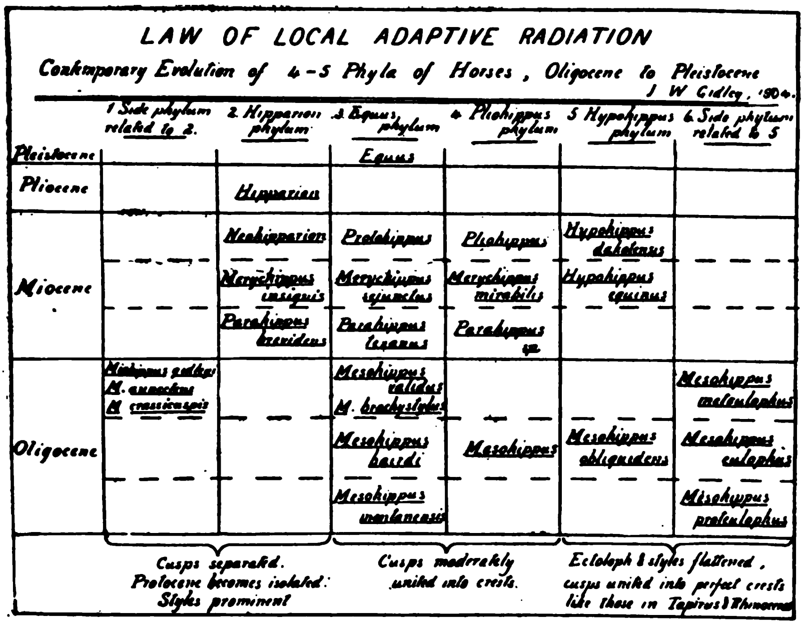

FIG. 4.

The Polyphyletic Law Illustrated in the Evolution of the Equidae of North America

In the Miocene are at least four contemporary phyla of horses, the extremes being represented by the forest-living horse *Hypohippus*, and the light-limbed Neohipparion; the central form, *Protohippus*, apparently leading to *Equus*.

This true *Equus* line separated off from other horses as far back as the base of the Oligocene. In this period again five distinct contemporary phyla have already been found.

are not exactly determined (Wortman, Matthew). The supposed ancestry (Wortman) of the Felidæ in the Eocene in the problematical genus *Aelurotherium* has been disproved (Matthew).

Still undiscovered or unrecognized in the Eocene both of America and Eurasia are the ancestors of the true Rhinocerotidæ which suddenly appear in the Oligocene. The Basal Eocene ancestry of the Rodentia is still satisfied only provisionally by the family Mixodectidæ, belonging to the somewhat hypothetical Proglires (Osborn[3]); the teeth seem to be approaching those of the Rodents but knowledge of

2 *The Extinct Camelidae* Bull. Amer. Mus. Nat. Hist., vol. x, 1898, pp. 93-142.
3 Bull. Amer. Mus. Nat. Hist., xvi, 1902.

the skeleton is necessary to determine whether they may not after all be remotely related to the Lemurs (order Cheiromyoidea) as Cope and Wortman have suggested. Wortman is strongly of the opinion that the Eocene Primates (Notharctidæ, Anaptomorphidæ) are not Lemuroidea, and that the former family are distinctly South American; this also requires confirmation.

Search for the exact relations and points of connection between the Carnivora and Creodonta, has thus far been entirely without definite success; in other words, the true Carnivora seem to be as separate from the Creodonta as the true Perissodactyla are from the Condylarthra.

As regards the Artiodactyla, as yet very little is known of the Middle and Lower Eocene stages, among which it is especially important to test the truth of Scott's[4] broad generalization that the American Artiodactyla should all be regarded as affiliated to the Tylopoda as a stem group from which not only the Camelidæ evolved but also the other distinctively American Artiodactyls, such as the Oreodontidæ, and that even the traguloid forms are of tylopodous affinity and merely parallel or analogous to the true Tragulines of Eurasia. There is no doubt that such an adaptive radiation from a Tylopod stem is possible and that there is considerable actual evidence for it in the morphology of the skull of these various distinctively American Artiodactyls; but the hypothesis is such a bold one that we must wait for more material.

The chief problem of all, which is also the problem of the European palæontologists, is the source and origin of the modern Lower Eocene fauna as a whole, namely, the Carnivora, Perissodactyla, Artiodactyla, Primates, and Rodentia.

American Oligocene Faunas

Our Oligocene (Lower Oligocene Infra-Tongrien, Middle Stampien, and Upper Aquitanien, of Europe) has been the most thoroughly explored of any of the periods, owing to the richness of its fossil fauna.

The chief geological result is the separation of the

4 *The Selenodont Artiodactyles of the Uinta Eocene*: Trans. Wagner Free Inst. Sci. Phil., vi, 1899, p. 100.

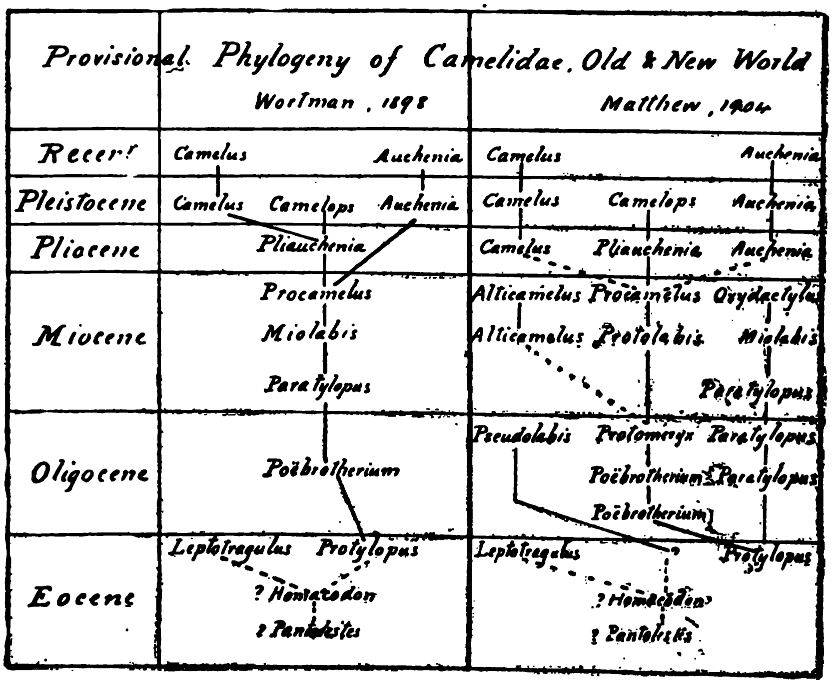

FIG. 5.

The Polyphyletic Law and Local Adaptive Radiation Illustrated in the Phylogeny of the Camels.

On the left is illustrated the older monophyletic view held as recently as 1898; on the right, the newer polyphyletic view developed in 1904 showing three distinct contemporary lines of Camelidae.

fluviatile or channel beds, with chiefly lowland or bottom fauna, from æolian or backwater sediments, chiefly with a plains and cursorial fauna. The three subdivisions originally observed by Hayden and Leidy are thus divided as follows:

I. Fluviatile or Channel Beds.	II. Æolian or Backwater Sediments.
Upper, Protoceras beds.........	..Leptauchenia beds.
Middle, Metamynodon beds.......	.Oreodon beds.
Lower, Titanotherium beds.	

This separation was chiefly brought about by Matthew's careful analysis of the animals coming from these respective

beds, the former (I) including lowland, forest and river-bottom, and aquatic animals, the latter (II) the animals of the plains and uplands. The John Day beds of Oregon apparently contain an overlapping fauna partly equivalent to the Upper Oligocene and partly to the Lower Miocene.

The already well known (Cope, Filhol) and close zoogeographical relationships during the Oligocene of North America and Europe are strengthened by the discovery of European Anthracotheriidæ, Mustelidæ (*Bunaelurus*[1]) and Erinaceidæ (*Proterix*, Matthew[2]) in America, and of the American Titanotheriidæ in Europe[3]. This leaves as the chief families in Europe still unknown in America the Palæotheriidæ, Anoplotheriidæ, Tragulidæ.

Our faunal knowledge has been especially enriched by the discovery and description of the hitherto unknown microfauna of the Titanotherium beds (Douglass[4], Matthew[5]) which includes archaic, *Centetes*-like forms, as well as *Erinaceous*-like forms.

The main phylogenetic results are the following. The Creodonta have been definitely traced to their extinction in the Hyænodontidæ (Table II). Among the Canidæ the ancestral line of *Cyon* (Dholes) has almost certainly been recognized in this period in the genus *Temnocyon* (Wortman and Matthew[6]) (Fig. 6). No trace of Edentata has been found, the forms formerly described as such now being known to be the peculiar Chalicotheriidæ, probably of Perissodactyl affinities. The rhinoceroses have been traced back in the Lower Oligocene to animals (*Trigonias*) with several incisors as well as with canine teeth (Osborn[1], Lucas[2]).

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1 MATTHEW, W D. *On the Skull of Bunaelurus*, Bull. Amer. Mus. Nat. Hist., xvi, 1902, pp. 137-140.

2 *A Fossil Hedgehog from the American Oligocene* Bull. Amer. Mus. Nat. Hist., vol. xix, 1903, pp. 227-229.

3 TOULA. *Ueber neue Wirbelthierreste aus dem Tertiar Oesterreichs und Rumeliens*, Zeitschr. d. Deutsch. geolog. Ges., Jahrg. 1896, pp. 922-924.

4 *Foss. Mamm. White River.* Trans. Amer. Philos. Soc, n. s., vol. xx, 1901, p. 1-42.

5 *The Fauna of the Titanotherium beds.* Bull. Amer. Mus. Nat. Hist., vol. xix, 1903, pp. 197-226.

6 Bull. Amer. Mus. Nat. Hist., vol. xii, 1899, pp. 139-148.

1 *The Extinct Rhinoceroses.* Mem. Amer. Mus. Nat. Hist., vol. i, 1898, pp. 75-165.

2 *A New Rhinoceros. Trigonias Osborni.* Proc. U. S. Nat. Mus. xxiii, No. 1207.

The law of local adaptive radiation with its polyphyletic consequences has completely altered our conception of several Oligocene families, as follows. The Titanotheriidæ (Osborn[3]) break up into four genera, which evolve independently from the base to the summit of the Oligocene, namely, *Titanotherium*, *Megacerops*, *Symborodon*, and *Brontotherium;* divergence is indicated by dolichocephaly and brachycephaly as well as by other characters (Fig. 7). Similarly the Equidæ break up into four and possibly five distinct contemporary phyla, and it now begins to appear probable that the line giving rise to Equus, separated off from the other horses as early as the Lower Oligocene (Osborn, Gidley; Fig. 4). The Oreodontidæ, represented by two phyla in the Upper Eocene, now present three phyla, namely, *Agriochoerus*, *Oreodon*, *Leptauchenia* (Matthew). Three phyla of Camelidæ are also recognized, namely, those represented by *Paratylopus*, *Poebrotherium*, and *Pseudolabis* (Matthew, Fig. 5). Similarly among the Felidæ, the Machærodont division, the only felines represented in America at this time, breaks up into the stout-limbed *Hoplophoneus* series ancestral to *Machaerodus* and *Smilodon* the slender-limbed *Dinictis*[4], and a third series represented by *Nimravus* (Fig. 6).

Among the gaps in the Oligocene is the entire absence of Primates, the genera *Laopithecus* and *Menotherium*, formerly associated with the Primates, proving to be singularly primitive tritubercular Artiodactyls. An important problem is the actual relationships of the Artiodactyl genera *Protoceras*, *Leptomeryx*, *Hypertragulus*, and *Hypisodus*, which according to Scott's theory above alluded to, represent with the Oreodontidæ an independent radiation of American Artiodactyla wholly without affinity with the European Tragulines.

THE MIOCENE FAUNA.

In our Miocene, equivalent to the Langhien (Orléanais), Helvétien (Sansan, Simorre), and Tortonien (Grive St. Alban, Bamboli) stages of Europe, the most exceptional pro-

3 Bull. Amer. Mus. Nat. Hist., xvi, 1902, pp. 91-109.
4 MATTHEW. *Fossil Mammals of the Tertiary of Northeastern Colorado* Mem. Amer. Mus. Nat. Hist., vol. i, pt. vi, 1901.

gress has been made in the distinction of the geological and faunal zones. Ten years ago the accurate geological observations of Hayden were overlooked, and it was believed that formations equivalent to the Middle and Lower Miocene of Europe were sparsely if at all representetd. Now three faunal stages are clearly recognized (Scott[1], Matthew[2], Gidley[3]), namely: Lower (Rosebud beds), in which the animals are still sparsely known, Middle (Deep River beds), in which the fauna is becoming more fully known, Upper (Loup Fork beds), in which a very rich fauna is now fully known. Each of these divisions is distinguished by specific stages in the evolution of the horses, rhinoceroses, camels, oreodonts, rodents, and carnivores. These chronological successions derived from geology have already yielded very important new biological results.

The zoogeographical relationships with Europe have been strengthened by the discovery for the first time of ***Dinocyon*** (Matthew[1]), of a new species of rhinoceros (***Teleoceras bicornutus***[2] Osborn), closely similar to the ***Teleoceras aurelianensis*** of the Lower Miocene of France, by the recognition of new Mustelidæ (Lutra), and of the Castoridæ (***Dipoides***). The Proboscidea, now known to be of African origin, are not certainly found in the lower and sparsely known in the middle, but are fully represented in the upper beds. In the middle beds appears ***Mastadon productus***, rather derivable from the *Palaeomastodon* of Africa than from the ***M. angustidens*** of France.

Our views as to the Miocene climate have also undergone a change, owing to the recognition that most of these deposits are fluviatile and æolian rather than lacustrine (Matthew, Gidley[3]), as evidence of a dry climate, marshy

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1 *The Mammalia of the Deep River Beds.* Trans. Amer. Philos. Soc., xviii, 1895, pp. 55-185.
2 *Foss. Mamm.* of the Tertiary, etc. Mem. A. M. N. H., vol. 1, 1901.
3 *New or Little Known Mammals from the Miocene.* Bull. Amer. Mus. Nat. Hist., xx, 1904, pp. 241.
1 *A Skull of Dinocyon from the Miocene of Texas.* Bull. Amer. Mus. Nat. Hist., vol. xvi, 1902, pp. 129-136.
2 *New Miocene Rhinoceroses.* Bull. Amer. Mus. Nat. Hist., vol. xx, 1904, pp. 307-326.
3 *New or Little Known Mammals from the Miocene of South Dakota* Bull. Amer. Mus. Nat. Hist., vol. xx, 1904, pp. 241-268.

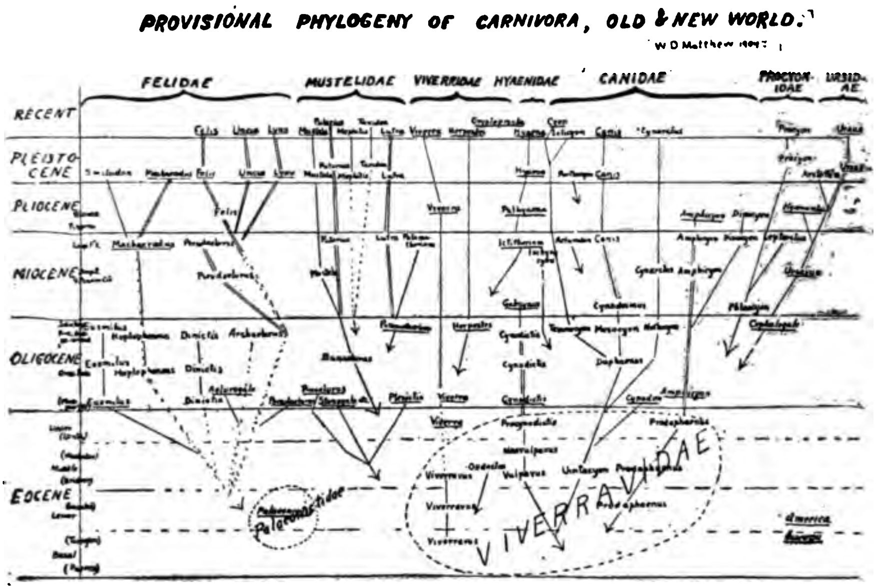

FIG. 6.

The hypothetical phylogeny of the Carnivora illustrating especially the great antiquity of some of the modern genera of dogs, such as *Cyon*, which separated off from the other Cranidae in the base of the Oligocene if not in the Eocene. This table includes also the European Carnivora and is of a temporary value. *Palaeonictis*, although a Creodont may possibly be related to the Felidae.

plains, and drifting sands, rather than of the moister climatic conditions inferred from the older lake basin theory.

Among the chief phylogenetic results are the addition of at least four kinds of Canids (Fig. 6) and the tracing back of the Procyonidæ to the Lower Miocene *Phlaocyon* (Matthew[4]), tending to unite this phylum more closely with the Canidæ. The Mustelidæ are now represented by *Mustela* and *Lutra*. The Viverridæ and Ursidæ are still wholly unrepresented in America although evolving contemporaneously in Europe. Among the distinctively American Artiodactyls the Cervidæ are now recorded in the Middle Miocene (*Palaeomeryx*), a fact however still requiring confirmation. In this connection should be mentioned the discovery of the full characters of the genus *Merycodus* (*Cosoryx*),

4 *Foss. Mamm* of the Tertiary, etc. Mem. A. M. N. H., vol. 1, 1901.

which with ***Blastomeryx*** as the new family Merycodontidæ has been regarded by Matthew[5] to be more nearly related to the American Antilocapridæ than to the European Cervidæ, although its deerlike horns certainly suggest Cervine relationships. The Camelidæ until recently considered monophyletic have been shown to be in a marked degree polyphyletic[6], the Lower Oligocene ***Paratylopus*** giving rise to two phyla, one of which includes the "giraffe camel," ***Alticamelus*** (Matthew[1]), which presents a remarkable analogy in the elongation of its neck and limbs with the giraffes of Africa; similarly *Proebrotherium* splits into three phyla (Fig. 5, Matthew). Similarly the Oreodont, and Agrichœrine phyla have disappeared without leaving successors. The rival cursorial Hyracodontidæ and aquatic Amynodontidæ having died out, the true Rhinocerotidæ (Fig. 3) split up into three series, one including the extremely long-skulled and long-limbed types, possibly related to the true ***Aceratherium incisivum*** of Europe, a second including excessively broad-skulled types (genera *Aphelops* and *Peraceras* Cope), and a third including the short-footed (brachypodine) types (*Teleoceras*), almost certainly of European origin. The Tapiridæ are still sparsely known. The aberrant Chalicotheriidæ terminate in an Upper Miocene species which nearly equals in size the Lower Pliocene ***Ancylotherium*** of the Pikermi. The most astonishing discovery among the Rodentia is that of a member of the Mylagaulidæ with a very large horn core on the front portion of the skull (genus *Ceratogaulus* Matthew[2]).

The principal work still to be done in our Miocene is the following: to ascertain more fully the character of the Lower Miocene fauna, which is still unknown; to fix the date of the arrival of the earliest Proboscidea either early in the Middle or in the Lower Miocene; to trace the ancestry of the typical dogs; to ascertain the origin of the Cervidæ, which will probably prove to be Asiatic, as well as the origin of the peculiarly American Antilocapridæ.

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5 *A Complete Skeleton of Merycodus.* Bull. Amer. Mus. Nat. Hist., vol. xx, 1901, pp. 101-129.
6 *Notice of Two New Oligocene Camels.* Bull. Amer. Mus. Nat. Hist., vol. xvi, 1902, pp. 617-635.
1 *Foss. Mamm. of the Tertiary, etc.* Mem. A. M. N. H., vol. i, pt. vi, 1901.

The Pliocene Fauna.

Equivalent to Messinien (Pikermi), Plasancien (Casino), Astein (Rousillon), Sicilien (Val d' Arno sup.)

Our limited American Pliocene fauna still stands in sad contrast to the rich succession of Pliocene mammals of Europe. The Palo Duro mammals which Cope included in the Pliocene have proved to be Upper Miocene. Recent geological and palæontological work (Gidley[3]) shows that the only true Pliocene formation and locality is that of the Blanco beds of Texas, 75 feet in thickness, as against the rich successive Pliocene series of Europe. Nor are any species of *Equus* found here, as Cope supposed, and as might be expected from the presence of *Equus* (*E. stenonis*) in the Upper Pliocene of Europe. The chief faunal distinctions are the entire disappearance of the Rhinocerotidæ and the appearance of South American Mammals.

The zoogeographical changes are well known to enter a new relation by the invasion of the South American Edentata, namely, *Glyptodon*, *Megalonyx*, *Mylodon*. Among these a new Glyptodont, *Glyptotherium texanum* has recently become known (Osborn[1]) from a nearly complete carapace and partial skeleton, which exhibits primitive affinities with the Eocene types of Patagonia. Among the Proboscidea the Stegodont stage appears in the so-called *Mastodon mirficus* of Leidy, indicating a late Pliocene age for the Blanco formation. In the marine Miocene of Japan (Iwasaki and Yoshiwara[2]) the remarkable discovery has been made of an anomalous skull representing a new family (*Desmostylidae* fam. nov.) either of hypsodont Sirenia or of Proboscidea, and Merriam[1] has recognized as a similar form occurring on the coast of California the genus *Desmostylus* first noticed by Marsh.

The phylogenetic series is all too limited, the horses

2 *A Horned Rodent* Bull. Amer. Mus. Nat. Hist., vol. xvi, 1902, pp. 291-310.

3 *The Freshwater Tertiary of Northwestern Texas.* Bull. Amer. Mus. Nat. Hist., vol. xix, 1903, pp. 617-635.

1 *Glyptotherium texanum* Bull. Amer. Mus. Nat. Hist., xix, 1903, pp. 491-491.

2 *Notes on a New Fossil Mammal* Jour. Coll. of Sci. Imp. Univ. Tokyo, vol. xvi, Art. 5, 1902.

1 *Science*, n. s., vol. xvi, Oct. 31, 1902, p. 714.

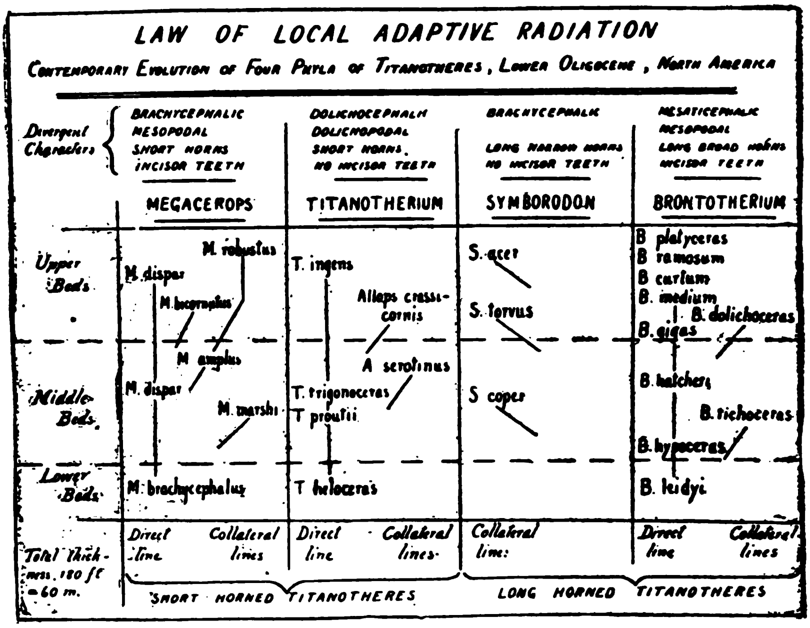

FIG. 7.

The law of local adaptive radiation illustrated in the four phyla of Oligocene Titanotheres, one or more of which gave off collateral branches.

Three of these phyla have now been shown to have a separate origin in the Middle Eocene.

being sparsely represented by species of *Neohipparion* (Gidley[2]) and a doubtful *Pliohippus*, the Camelidae by Pliauchenia, the Dicotylidæ by several pieces of *Platygonus*, the Carnivora by an *Amphicyon* and other doubtful species of Canidæ. The collateral lines of Camelidæ, so far as we know, died out, and the adaptive rediation of the true camels begins.

However, no generalizations can as yet be made from this scanty fauna; we are confronted with more gaps in our knowledge and more unsolved problems than in any other period. Among these, the direct ancestry of the South American cameloids (*Auchenia*) as well as of the true camels (*Camelus*) should be found. We also should find here the stages directly ancestral to the horse (*Equus*), be-

2 *A New Three-toed Horse*. Bull. Amer. Mus. Nat. Hist., vol. xix, 1903, pp. 465-476.

cause it now appears certain that Marsh's *Pliohippus* was an Upper Miocene and not a Pliocene animal, and was, moreover, apparently on a side line not leading directly into *Equus* (Gidley, Fig. 4). Thus not only is the Pliocene plains fauna sparsely known but the Pliocene forest fauna is wholly unknown.

THE PLEISTOCENE FAUNA.

Equivalent to (1) the Preglacial, Forest Beds of Norfolk (St. Prest. Durfort, Malbattu, Peyrolles), (2) Glacial, (Mid-Pleistocene, Lower Mid-Pleistocene), (3) Postglacial deposits of Northern Europe and Asia.

Here again American palæontology is far behind that of Europe as to knowledge of the chronological succession of deposits, and a vast amount of work remains to be done in the discrimination of geological and faunal stages, in the comparison of Eastern and Western cave—and sand— deposits, and in the coordination of the first appearance of man with that of the mammalian succession.

The advent of the true *Equus* marks the base of our Pleistocene, as shown in the sand deposits of the Western plains in the so-called *Equus* beds. The geographical distribution and remarkable adaptive variation of the Pleistocene horses have now been fully worked out (Gidley[3]), proving that there are ten species characteristic of different localities, and ranging in size from *E. giganteus* larger than any modern horse, to the diminutive *E. montezumae*. But nowhere in North America have horses been found contemporaneous with man.

Two chief advances have been made, first, the distinction of plains and river, from forest faunas; second, the exploration of two very remarkable cave deposits.

The Western plains fauna of the *Equus* beds or Lower Pleistocene (Matthew[1]) contains among the Carnivora, *Canis*, *Dinocyon*, *Felis;* among the Rodentia, *Fiber*, *Arvicola*, *Cynomys*, *Thomomys*, *Castoroides;* among the Edentata, *Mylodon;* among the Perissodactyla, three species of

3 *Tooth Characters and Revision of the Genus Equus.* Bull. Amer. Mus. Nat. Hist., vol. iv, 1901, pp. 91-142.
1 *List of Pleistocene Fauna from Hay Springs.* Nebr. Bull. Amer. Mus. Nat. Hist., vol. xvi, 1902, pp. 317-322.

Equus; among the Artiodactyla, two species of the Dicotylidæ; one species of the Camelidæ, and two of the Antilocapridæ (*Capromeryx*, a new form, Matthew), and *Antilocapra;* among the Proboscidea, *Elephas columbi* A similar plains fauna is that of Silver Lake, Oregon, which includes also two aquatic animals, *Castor* and *Lutra*. At Washtuckna Lake, Washington, is found a forest fauna which includes in addition to camels and horses, a badger, *Taxidea*-three species of *Felis*, two of *Alces*, one of the American deer, *Cariacus*, and one of the goat *Oreamnos* (*Haploceros*)

Our knowledge of the Western cave fauna has been enriched especially by the discoveries of Sinclair[2] in California, in the Potter Creek Cave, probably of late Pleistocene age. This includes an extremely rich series chiefly of the mountain and forest type. Of fifty-two species, twenty-one are extinct, including a new member of the Ovinæ in the genus *Euceratherium*[3] (Sinclair). With these animals are associated relics possibly of human origin. In the East, the Port Kennedy Cave, also treated by Cope, has been exhaustively investigated by Mercer[4], and shown to contain fifty species of mammals, including chiefly forest types, among which are the *Mastodon americanus*, a tapir, and two species of *Equus*. Again no human remains have been found.

As regards phylogeny, the horses are evidently polyphyletic; but we have not as yet worked out the distinction between possible representatives of the horses, asses, and zebras. The Proboscidea have been clearly distinguished (Pohlig, Lucas, Osborn[5]) into four great types *Mastodon amercianus* in the Eastern and Middle States; *Elephas primigenius* in the North, practically identical with the north Asiatic Mammoth; *Elephas columbi* chiefly in the Middle States but also in the Southern, and *Elephas imperator* in the South and ranging north to the Middle States; these species represent profoundly different types both in skull

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2 *The Exploration of the Potter Creek Cave*. Univ. Calif. Publ. Amer. Archaeol. & Ethn., vol. 2, No. 1, 1904.

3 *Euceratherium*. Univ. Calif. Publ. Bull. Dept. Geol., vol. 3, No. 20, 1904, pp. 411-418.

4 *The Bone Cave at Port Kennedy* Jour. Acad. Nat. Sci. Phila., vol. xi, pt. 2, 1899.

5 *Evolution of the Proboscidea in North American*. Science, N. S., xvii, Feb. 13. 1903, p. 249.

and tooth structure. *Elephas columbi* is analogous to the *Elephas antiquus* type of Europe; the *Elephas imperator* is rather analogous to the *E meridionalis* of Europe. It is altogether probable that these species evolved in Eurasia and arrived fully formed in America. Naturally their geographical ranges overlap; but *E imperator* is never found in the extreme North, nor *E. primigenius* in the extreme South.

In conclusion, the great problem of all is the time of arrival of man amidst the Pleistocene fauna. This event is of such paramount importance that we must prepare for it by definitely determining the chronological stages of lower mammalian succession. At present man appears to be a late arrival, but personally I have a strong presentiment that human remains will be found in an earlier Pleistocene stage than is generally supposed.

CHIEF CENTRES OF ADAPTIVE RADIATION OF THE ORDERS OF MAMMALS.

I.—Jurassic Radiation (Partly Hypothetical).
- **Monotremata (Hypothetical, i. e. fossil forms not yet recognized.)**
- **Marsupialia (Triconodonta).**
- **Placentalia (Insectivora Primitiva, = Trituberculata.)**

II.—Marsupial radiation, upper Cretaceous and Tertiary.
- **Australia (chief centre), Antarctica and South America. Only one family (Didelphyidae) certainly known in North America and Eurasia.**

III.—First or lower placental radiation, upper Cretaceous and lower Tertiary (= Meseutheria Osborn.)
- **North America (chief centre), Europe, Africa (Creodonta), probably extending also to South America.**
  - ***a. Orders Certainly Recognized.***
  - **Creodonta, surviving to Lower Oligocene.**
  - **Tillodontia, Middle Eocene (possibly related to Rodentia).**
  - **Taeniodonta, probably related to Edentata Gravigrada.**
  - **Condylarthra, surviving to Middle Eocene.**
  - **Amblypoda, surviving to Upper Eocene.**

b. Orders not certainly known in Basal Eocene but probably belonging to this radiation.

Insectivora, giving rise to modern Insectivora.
Lemuroidea.
Rodentia, Not yet certainly known earlier than Middle Eocene.

IV.—Second or Higher placental radiation (= Ceneutheria Osborn), Middle Eocene and Tertiary.

A. Chief centres North America and Eurasia, migrating to Africa and South America.

a. Orders derived from first placental radiation.
Edentata from Radiation III (North America only).
Insectivora from Radiation I and III.
Rodentia.

b. Orders characteristic of second placental radiation.
Cheiroptera.
Carnivora (Fissipedia and Pinnipedia).
Primates, Anthropoidea, possibly from Radiation III.
Perissodactyla, Lower Eocene.
Artiodactyla, Middle Eocene.

c. Centres of origin unknown.
Nomarthra or Effodientia (Lower Oligocene of France, *Necromanis* Filhol.)
Tubulidentata (First appearing in Lower Oligocene of France, *Palæorycteropus* Filhol).

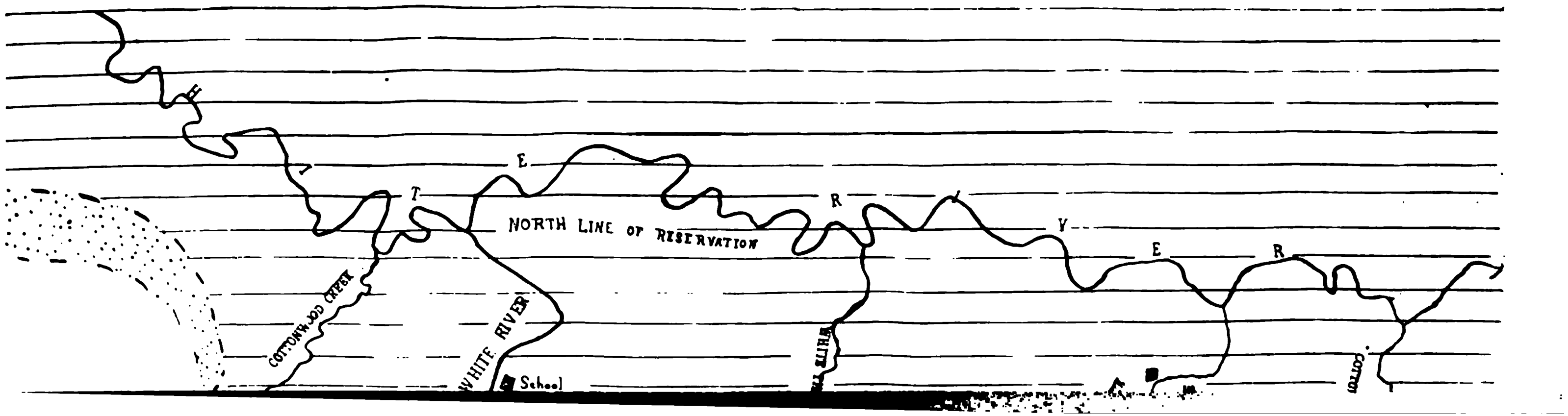
B. Chief centre Africa, migrating in upper Oligocene (Sirenia), lower Miocene (Proboscidea), and Pliocene (Hyracoidea) to Europe, to Asia (Hyracoidea). Also to North and South America (Proboscidea).
Sirenia, Middle and Upper Eocene.
Proboscidea, Middle Eocene.

Hyracoidea, Upper Eocene.
Arsinoitherium.
Barytherium.

C. Chief centre South America.

a. Autocthonous orders.
Litopterna.
Toxodontia.
Typotheria.
Astrapotheria.
Pyrotheria.

b. Autocthonous or derived orders, in part.
Edentata, Suborders: Lorigata (Glyptodontia and Dasypoda), Pilosa (Gravigrada, Tardigrada, Vermilingua).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NORTH LINE OF RESERVATION
COTTONWOOD CREEK
WHITE RIVER
School
WHITE
COTTO

Thus the degree of zoological kinship of the continents may be expressed as follows:

1. Close kinship of North America, Asia and Europe (= Holarctica), having all pre-Miocene Orders in common, and separated only by the independent radiation of certain families.
2. Separation of Africa as a pre-Miocene centre of at least three orders not found in Holarctica.
3. Strong separation of South America from the Eocene until the Pliocene. Affiliation with Australia.

SOME GEOLOGICAL OBSERVATIONS ON THE CENTRAL PART OF THE ROSEBUD INDIAN RESERVATION, SOUTH DAKOTA.

By ALBERT B. REAGAN, Mora, Wash.

PLATE XII.

CONTENTS.

The region under consideration extends from Valentine, Nebraska, north to beyond White river, the northern boundary of the Rosebud Indian reservation; and both to the east and to the west of the White Thunder day school of that reservation a distance of about twenty-five miles. It is wholly within the "high plains" region, and is a grazing country without trees of any sort except along its streams. Geologically the following formations are exposed: the

Recent and Glacial; the Ogallala, Arikaree, and Oligocene Tertiaries; and the Pierre shales of the upper Cretaceous.

SECTIONS.

1. Section on the bluff east of Little Oak Creek, one mile east of the Ring Thunder day School.

		Feet	Inches
	Oligocene:		
1.	Yellow thin-bedded, somewhat porous limestone....	40	
	Pierre Shales:		
2.	Black shale streaked with yellow bands of iron ore..	10	
3.	Black shale, carrying concretions of iron in which are occasional Baculite fragments...............	40	

2. Section in the Bad Lands four miles due east of the Little White river issue house.

		Feet	Inches
	Arikaree:		
1.	Sand	15	
	Oligocene:		
2.	Light colored shale	90	
3.	White, concretionary stratum....................		4
4.	Light colored shale having an olive cast when wet..	5	4
5.	Hard white limestone stratum....................		6
6.	Brown colored shale	4	
7.	Light gray shale, weathering brown...............	10	
8.	Cream colored shale	10	
9.	Jointed, very hard, yellow shale..................	18	

3. Section in a well at Butter Creek.

	Recent:		
1.	Yellow clay (bones of the buffalo and deer)........	10	
	Pierre Shales:		
2.	Black to gray shale.............................	12	

4. Section on west side of Oak Creek, eight miles south of Bad Nation school house.

	Glacial?:		
1.	Light colored clay................................	10	
2.	Gravel		6
3.	Light colored clay		6
4.	Dark clay	1	
5.	Cobblestone-gravel stratum.......................	3	
	Pierre Shales:		
6.	Grayish-black shales	120	

5. Section in the valley south of Little White River, one mile above the mouth of Cut Meat creek

	Recent:		
1.	Light colored, finely laminated clay..................	2	
2.	Dark forest ground		8
3.	Yellow sandy clay	1	
4.	Fine to coarse, banded, cross-bedded, white sand	10	

6. Section at the water's edge, south side of Little White river, one and one-fourth mile north of Ring Thunder school house.

	Recent:	
1.	Black earth	1
2.	Gravel, light colored sands and clays, resting unconformably on the next	20
3.	Partly lithified, light colored clay	10
4.	Bedded gravel interbedded with bands of light colored sand. This stratum rests unconformably on the next following	12
5.	Brown, clayey material, unconformable both with the stratum above it and the one below it......	3
6.	Grayish black shales	10+

7. Section one mile northwest of the White Thunder day school.

		Feet	Inches
	Oligocene (near base of the formation):		
1.	Clayey shale in which are interstratified bands, three to five inches in thickness, of the same material containing some iron ore. The bands are harder than the other shales and show an iron-rust, red ochre color when wet............	7	

8. Section on Butte one mile southeast of the White Thunder day school.

		Feet	Inches
	Arikaree:		
1.	Greenish, shaly to thin bedded very porous sandstone	6	
2.	Bluish to greenish, somewhat porous sandstone....		10
3.	Greenish sandy shale	15	
4.	Clayey, thin-bedded, cream colored sandstone.....		14
	Oligocene:		
5.	Yellowish chocolate, cream colored, and pinkish shales	70	
6.	Greenish shales to thin-bedded, often porous, sandstone	4	
7.	Cream colored shales	4	

9. Section two and one-half miles south of the White Thunder day school.

		Feet	Inches
	Arikaree:		
1.	White to gray flint, in which are numerous gastro-		

		Feet	Inches
	pod shells. This flint is the cap rock of many of the Arikaree buttes of the region adjoining the Oligocene outcrop	4	
2.	Clayey, reddish brown sandy shale to massive sandstone breaking down in terraces in some places	25	
3.	Unseen	60	

10. Section on Rattle Snake butte, four miles south of the Butte Creek school house.

	Arikaree:	Feet	Inches
1.	Very hard, massive to thin-bedded sandstone, so firmly cemented with silica that the rock is a quartzyte. (The dip of these sandstone strata is toward the north	8	
2.	Volcanic ash	10	
3.	Hard, light brown, massive to thin-bedded, often laminated, cross-bedded sandstone (dip southeast)	140	
	Oligocene(?):		
4.	Unseen	100	
	Pierre Shales:		
5.	Unseen	40	

11. Section in the Bad Lands just across the river from the Ring Thunder day school. Dip of strata north.

	Arikaree:	Feet	Inches
1.	Sand and sandy clay	40	
	Oligocene:		
2.	Light colored shale, weathering reddish on exposed surfaces, the reddish color being due to the particles of iron scattered through it	40	
3.	Light colored, occasionally greenish tinged, soft shales, banded with harder streaks of practically the same material, in which are occasional iron nodules. On weathering the whole series breaks down into light chocolate to pinkish and cream colored potato hills and cones, when isolated; and when joining a mesa, into smooth, symmetrical hogbacks	50	
4.	Same as three above except the shales have not the pinkish, greenish tinge in their color	45	
5.	Yellow, clayey shales, containing so many iron nodules that, at a distance, the exposure has a brownish to a red rust, red ochre color, due to the broken pieces of iron scattered over its face	10	
6.	Unseen	10	
	Pierre Shales:		
7.	Grayish-black shales (Baculites)	10	

Total thickness of Oligocene here............	155	
Total thickness of section....................	215	

12. Section from the mouth of White Thunder creek to the top of Mastodon buttes (Three Points) at the head of Oak creek, one mile east of the artesian well.

	Feet	Inches
Arikaree:		
1. Very hard, calcereous-cemented sand rock, in which are sticks, bones of birds, fishes, and animals, and fragments of turtle shell, cork-screw fossils, masses of fibers and rootlets, etc. This stratum is massive, and is the topmost rock of a great part of the Arikaree formation of the region. It is the Daimonelix beds of the Nebraska geologists, so named on account of the fossil cork-screws (Daimonelix) found in it................	8	
2. Partly lithified sand, having the appearance of dune origin (camel, horse, birds, turtles).............	10	
3. Partly lithified sand of stream origin. The water sorting, laminating, and cross-bedding are all in evidence, (mastodon, horse, camel, etc.)*.......	8	
4. Partly lithified sand	40	
Oligocene:		
5. Light colored to pinkish shales (estimated)........	234	
Pierre Shales:		
6. Dark gray shales (estimated).....................	400	
Total	700	

13 Section from the bridge northeast of Rosebud to the top of the hill in the cut on the Rosebud Boarding school wagon-road. Altitude estimated.

Ogallala(?):		
1. "Mortar beds" of grit and calcarceous magnesian limestone permiscuously mixed	20	
Arikaree:		
2. Partly lithified ash gray to brown sand.............	60	
3. Buff colored sand forming a perpendicular bank on the Rosebud side of the stream................	60	
Total	140	

Formations in Detail

The *Pierre Shales* of the Cretaceous system underlie the Tertiary formations wherever found and are the country rock in all places where the Tertiary has been removed by

* The writer sent the University of Indiana twenty-nine boxes of fossils from this locality.

erosion. As is shown by the map they cover all the lower country of the region and extend across the area at the head of Oak creek to the Kaya Paha (this latter was not positively determined to be Cretaceous). The formation is composed, principally, of dark gray shales containing brachiopod shells and Baculites. A bluff of this formation on the south side of White river near the mouth of White Thunder creek is three hundred feet in hight; Baculites were obtained from its summit. The entire thickness of these shales is not exposed in the region examined, although their thickness there must exceed 600 feet.

The shales are destitute of value, for they contain no stone, no building material, no water. The area they dominate is an alkali, salt grass, prairie-dog town country.

The *Oligocene formation* forms the clay bad lands lying between the Cretaceous and the Loup Fork (Arikaree and Ogallala) formations, forming a rough broken strip which runs in a general east and west direction across the country. It once covered the whole region as is shown by detached patches beyond the confines of the area mapped, but has subsequently been removed. Its strata are usually horizontal. They are composed, for the most part, of light colored to pinkish soft shales with which are interstratified bands of harder material carrying some iron. Sandstone strata, however, are occasionally exposed. The formation beginning with a cobble-stone gravelly stratum, lies unconformably on the Pierre shales. Its shales break down and so slack in water that they are readily carried off with it. When mixed with sand in the right proportion, the clays formed from the shales make a hard cement, which the Indians use in plastering. The cream colored to pinkish colored potato hills, cones, castles, terraces, and hog-backs, formed by the breaking down of these shales, make this strip picturesque.

The formation has the appearance of having been begun by river action. Later, judging from the fineness of the material, the area must have become a deep lake and remained such for a long period. Finally, the lake was filled with sediment till the region reached the swamp stage; the deposition then ceased.

The *Arikaree Formation* overlies and rests unconformably on the Oligocene series. It covers the entire southern half of the area mapped, save where it is removed by erosion at the head of Oak creek. Farther to the north several detached patches also occur. It probably once covered the whole region, but must have been very thin along the northern border, as the exposures show that it gradually thinned toward the north. At Valentine, Nebraska, it is over 400 feet in thickness, while at the artesian well it is less than 160 feet. It is composed mostly of sand in various stages of hardness, ranging from the very hardest, unmetamorphosed rock in the Rattle Snake buttes to wholly unlithified sand in many other places. The latter, however, is packed so hard by pressure that a pick can hardly be driven into it. At all places where the whole series is exposed, it is found to be capped with a very hard calcium cemented sand rock from eight to twenty feet in thickness, except in the Rattlesnake Butte region where it is quartzyte sandstone. On the whole it seems to be dry delta, dune, and river-channel formation instead of lake deposit, as was formerly believed. The whole region seems to have reached the ponded stage at the close of the epoch. The strata thicken and thin alternately. They are often fan shaped. Many that are very thick pinch out in a short distance. Many show water sorting; some only for a little ways, others throughout the entire exposure. Others are composed wholly of fine dune sand; while others are heterogeneously mixed. Many show cross-bedding. In some places the strata pitch at a high angle one way for a little distance and at another angle a little farther on, notwithstanding that the Oligocene immediately underlying them is horizontal. In many other cases the strata dip in all directions from a common center, the formation indicating that it is likely an alluvial fan deposit.

So far as the writer could determine, there is no evidence that the formation is lake deposit. On the contrary, land snails, bones of the horse, camel, mastodon, and other land animals, together with the dune material, seem to indicate that it is stream, pond and æolian in origin.

From the observations of the writer, which were not

extensive enough to form any definite conclusion, it would seem that possibly a large stream flowed to the Gulf along the line of the sand deposits, the deposits being the debris left by its ever changing channel. A re-elevation of the central plain, after a long lapse of time, diverted the drainage and left the region, first, a ponded area as is shown by the pond-holes, and, then, arid land.

Again, the origin of the deposits might be explained by another hypothesis as follows: That after the re-elevation of the Rocky mountains just before or at the beginning of the Loup Fork epoch, the streams, flowing east from the continental divide, had not, as yet, formed permanent channels across what is now our western plains. Consequently, after flowing rapidly down the mountain slopes, they spread out on reaching the slack-water region of the plains forming dry deltas or alluvial-fan deposits. This they continued to do till time and re-elevation of the plains region caused them to cut permanent channels to the Mississippi river and the gulf of Mexico.

The *Ogallala (?) formation* was found exposed in a cut on the Rosebud-Boarding School wagon road one-half mile northeast of Rosebud. In general appearance and in composition it resembles the "mortar beds" of Kansas very much. It is essentially a limestone of the calcareous magnesian type containing many impurities. The limestone is wavy, looks much as if it had been run through a crimping machine before hardening, is somewhat continuous in stratum form, and, besides being gritty itself, is intermixed with grit and sand.

In this formation the writer found bones of the mastodon, horse and camel, fragments of turtle shell, and the bones of birds.

In places the limestone of these beds is used for building purposes, for which it is said to be a good rock.

On the map (plate XII.) these beds and the underlying Arikaree are mapped together as Loup Fork Tertiary.

Glacial (?) debris, rock, which seemed to be of glacial origin, was noticed at several places on the bluffs of lower Oak creek. As the great glacier extended to the Missouri adjacent, it is highly probable that a glacial lobe crossed

over to the White river—Oak creek side. It will necessitate more research work, however, to determine this fact.

The *Recent formation* (not mapped)extends out on the bluffs on either side of White river for quite a little distance. It is the surface rock in all the valleys wherever the valley widens out. Along White river and Little Oak creek it covers the meander region. The bluff formation is probably Champlain in age, some being probably even Glacial. The formation in the valleys is more recent and extends in time to the present. Little Oak creek is now building up its lower valley; and White Thunder creek its valley in its middle course. The whole formation, whether in the valley or on the bluffs, is of river origin.

To this age of rocks seems to belong the Tertiary debris from the broken down mesas and bad lands. Though patchy, this debris covers at varying thicknesses a considerable part of the area marked Cretaceous; the Tertiary, however, is not in "situ" nor in thickness enough to determine the surface age.

Resume: As the Cretaceous period neared its close the surface of the region became dry land and was such for a long period as is shown by the then eroded surface. The region then, in Oligocene times, began to fill with debris of the gravelly cobblestone type. Later it apparently became laked, and the soft fine-grained shales were deposited. While this was going on, fresh-water fish and gigantic turtles skimmed the waves and tropical animals roamed along the beach. After a long lapse of time, the region again became land and was much eroded. Another period of deposition then, in Loup Fork times, set in. The whole area was flooded with sand. This was deposited at intervals till it reached a thickness of more than 400 feet in the vicinity of Valentine, Nebraska. Throughout the whole time the region seems to have been in a swamp or ponded state. As the climate was tropical, there roamed over the marshy areas and through the jungles the tiger, horse, hyena, camel, mastodon, and the many other tropical animals of that epoch, as is shown by their fossil remains. The region was left ponded at the close of this epoch. In the succeeding epoch the present streams cut their channels to about their

present depth. In the Champlain epoch they refilled them or were so filled with water that they deposited debris far out on the adjoining mesa lands. Since then stream action and deposition have been going on about as now.

Bad Lands.

The bad lands are along the Oligocene outcrops. They are typical "mauvaises terres," but of course are less extensive than those farther west. They are almost destitute of vegetation; and are chiefly noted for their picturesqueness and for their being the home of the gray wolf and the coyote.

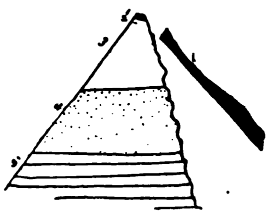
Buttes.

The buttes are situated upon the Oligocene along the break line of the Loup Fork, the strip having a general east and west trend. The buttes are conical or rectangular and flat topped, depending upon the hardness of the cap rock; the latter usually have their longest axis parallel with the nearest stream. The rectangular buttes in the vicinity of the White Thunder day school and those in the Robinson bad lands are capped with flint. The Rattlesnake buttes are capped with quartzyte sandstone. The conical buttes are generally capped with the Daimonelix beds of the Arikaree formation where they have not been removed by erosion. The buttes occupy the inter-stream spaces and range from 200 to 300 feet in hight.

It would seem from the observations that the flint and quartzyte capped buttes represent ponded areas of Arikaree times; the Daimonelix beds, sand dune and stream regions, the flint and quartzyte sandstone having been formed under water. This opinion is strengthened by the fact that the flint contains snail and turtle shells; the Daimonelix beds and sand areas, the bones of land animals. This difference in the formation of the original surface has been a leading factor in determining the course and position of the streams. The inter-ponded spaces, though being the higher ground, were less hard and have yielded more readily to erosive action; hence are now the valleys.

Rattlesnake Butte.

The Rattlesnake buttes were so named on account of



An east and west section through Rattlesnake Butte, showing the displaced rock to the north. Explanation: 1, quartzyte sandstone; 2, volcanic ash; 3, sandstone; 4, Oligocene shales; 5, Pierre shales. 1-3 are Loup Fork Tertiary. Altitude 300 feet.

the great number of rattlesnakes found there. At any time in summer the "rattlers" can be seen basking in the sun by the hundred. The cap rock of these buttes, as we have seen, is quartzyte sandstone. On the longest and highest butte, called Rattlesnake butte, it is very thick, and the strata are usually massive. This butte has had a geological accident in the recent past. It has been split in two along its longer axis, and its northern half has slid down the slope to the north, so that what was once the top is now the north face of the bluff, the rock dipping north 45 degrees. Thus tilted, the broken edge forms a ridge parallel to the remaining original top, a narrow valley occupying the intervening space.

Another geological accident awaits this butte in the near future of geologic time. It will then loose its top. This top is very narrow, ten to twenty feet wide and already has a dip of ten degrees toward the north, while the strata immediately underneath dip south.

Minerals.

So far as the writer knows there are no minerals in the region worth mentioning, he not having paid any attention to minerals in his investigations. He believes, however, that the Miocene (Oligocene) shales which the Indians use in plastering might prove of value in the making of cement. Besides this possibility of the clays (shales) being of value, placer gold is said to exist in the gravels at the mouth of Oak creek.*

* Some volcanic ash was noticed at several places, but the quality and quantity were not determined.

Soil.

The soil on the Oligocene formation and on a great part of the Cretaceous is very poor; but in the valleys and in the Loup Fork districts it is good, producing excellent crops whenever there is a sufficient amount of rainfall.

Water.

The water of the Cretaceous country is bitter to the taste and usually contains alkali, sometimes in such quantities that it kills stock or "alkalies" them, that is, causes them to loose their hoofs. The water of the sand districts has a good taste and is usually wholesome. Here the water for ordinary drinking purposes is furnished by comparatively shallow wells.

Throughout the entire region mapped if the water is running slow or is in a standing condition, it has a color similar to that of the water in a drain from a barnyard.

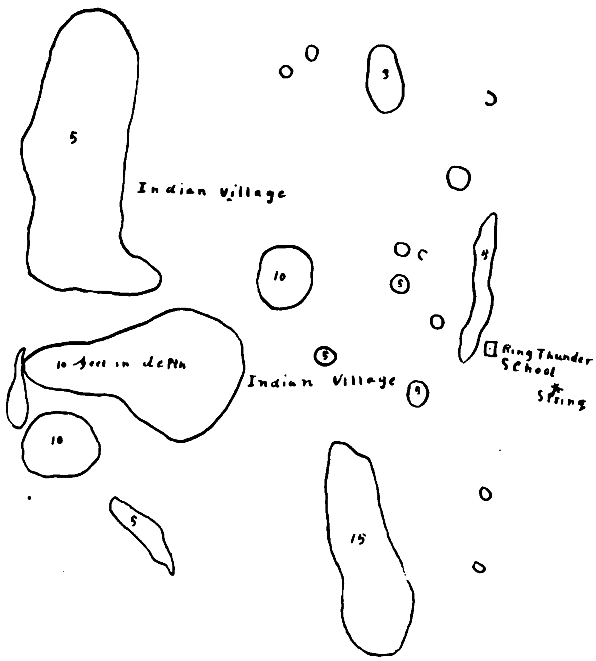
Sink Holes, Ponds and Lakes.

Dry sink-holes, ponds, and lakes of considerable size are scattered over the entire country. The sink-holes are due to underground drainage. In many places the last twenty to forty feet of the Oligocene, except the very last stratum, is often a very porous limestone; the same is also true of the lower strata of the Arikaree formation, except that the porous rock is sandstone. Consequently sink-holes are readily formed when the less porous rock is removed. In these holes after a big rain the water quickly seeps away and comes out below in springs. The ponds and lakes remain partly filled with water most of the year, though their dimensions are small compared with what they were formerly as is indicated by the old beach lines, especially in the case of the larger lakes. Some of the lakes have water in them throughout the year. The ponds and lakes are usually due to the unequal piling of the surface debris of the formation in which they occur. The most of them are on the Loup Fork formation.

Springs.

Most of the springs are located at the heads of the several streams along the contact lines between the Loup Fork and the Oligocene and the Oligocene and the Cretaceous. The springs of the former group are good drinking water,

those of the latter very poor. The latter have a soapy, clayey taste. The springs at the Ring Thunder day school besides having this taste is contaminated with the drainage from the Indian village above as is shown in the accompanying map of the sink-holes there. The Loup Fork springs in the vicinity of Valentine and Fort Niobrara and in Smith's canyon ten miles farther east are large. Those at Fort Niobrara furnish water for the fort, and the Smith canyon springs water over two thousand head of cattle. None of the springs possess medicinal properties.



North sink holes in the vicinity of the Ring Thunder School.
Scale ——— 300 feet.

Streams.

The streams are White river and its tributaries at the north, and the Kaya Paha and the Minichadusa at the south. All of the head streams of the Kaya Paha run above the Oligocene. Antelope creek is always clear and always has running water in it. The tributaries of the White

river all head at the top of the divide in the Loup Fork formation. They have water in their upper courses; but, as these streams are building up their middle courses with Loup Fork sand, the water, on reaching this part of its respective channel, sinks beneath the surface. White river itself is a large stream and is scarcely fordable on account of its quicksand. In many places its banks are very steep forming canyon walls. The water of the stream in the rainy season is white, the color being due to the white Oligocene sediment carried in the water from the Bad Lands. At other seasons of the year the water is practically clear.

Why the southern tributaries of White river are building up their channels in their middle course The streams flowing north from the vicinity of the artesian well cut through both the Loup Fork and the Oligocene formations in the first six or eight miles of their respective courses, falling in that distance from three hundred to three hundred and fifty feet. Then as the Cretaceous shales yield less readily to the erosive efforts, the fall is not maintained from there on. Hence a slack-water region is produced. In this the Loup Fork sands are deposited, except in high flood times when force enough is given to the water by its volume to carry the sediment with it to the master stream. The aridness of the region aids in building up this middle course.

Change of Drainage Courses. In the early history of Antelope creek it seems to have flowed north as the head stream of Little Oak creek, as its direction of flow would tend to take it to-day. Finally the Kaya Paha tapped it above the site of the boarding school and captured its upper tributaries, leaving Little Oak, its lower channel, to dwindle to a dry stream. The wind-gap through which the original stream seems to have run together with the great bend on Antelope creek at this point bears out this conclusion.

Antelope creek is now in danger of itself being tapped in the near future of geologic time by White Thunder creek. This creek runs, as it were, at right angles to the Antelope; that is, it would form a pretty good perpendicular to the Antelope if continued to it. The Antelope is at least

one hundred feet higher than White Thunder creek four miles away; and both streams, here, have their channels in the Loup Fork sands. It seems to be only a question of how long it will take, the result is evident.

Oak creek is likely to make a similar capture of the Kaya Paha at some time.

Why White river has all its tributaries on its southern side. The Cretaceous north of White river dips north and naturally causes the watershed of that stream on the north to be the bluffs on that side. In addition to this, the greater part of the strata to the north are Cretaceous shales, while to the south they are horizontal, softer, Oligocene shales and Loup Fork sands. The Tertiary being the easier eroded the river has cut its tributaries on that side.

Irrigation.

Irrigation is not carried on at all on the reservation; but could be in the valleys of White river and its larger tributary, Little White, also along Antelope creek, with but little expense. The valley of Little White is about a mile wide in its lower course; and, as the stream is at base level there and at the level of the valley floor, this whole valley could be made a garden. It would necessitate considerable fluming, however, to irrigate the bottom lands of Big White, as the master stream is usually called on the reservation, for the bluffs wedge in to the water's edge occasionally; but in the end it would pay. The land is of good quality and would be very productive if water could be got to it.

The Kaya Paha and its head stream, Antelope creek, have plenty of water and also flat valleys. It seems a shame that the Indians allow so much water to run to waste each year, when, if properly used, the government would not be compelled to feed and clothe them.

The creeks that are tributary to White river would furnish no water for irrigating purposes, not even by the storage reservoir system. Except in flood times, they are practically dry; and water stored in them seeps away in the sand that fills their channels. Side reservoirs in the little ravines having Oligocene or Cretaceous shales for a bottom are the only reservoirs that hold water for stock during the dry season.

NOTES ON THE DISTRIBUTION OF BRACHIOPODA IN THE ARNHEIM AND WAYNESVILLE BEDS.

By Aug. F. Foerste, Dayton, Ohio.

In the first volume of the Geology of Ohio, published in 1873, on page 397, Prof. Orton states that the lowest horizon at which *Leptaena rhomboidalis* (*Strophomena tenuistriata*) is found is at the very summit of the Cincinnati hills, or about 455 feet above low water. The geological horizon at which the *Leptaena* occurs at Cincinnati is fixed by the statement, on page 394, that at a hight of 425 feet above low water a belt of rock, two to ten feet in thickness, occurs which is almost entirely composed of the ventricose full-grown shells of *Platystrophia lynx* (*Orthis biforata.*) This Lynx horizon was considered as forming virtually the summit of the Cincinnati section, notwithstanding the occurrence of *Leptaena rhomboidalis* at a higher horizon. The reason is given on page 370, where it is stated that the greatest elevation above low water in the immediate vicinity of Cincinnati is given by the city engineer as 465 feet. Subtracting 15 feet for the drift covering at the surface we can certainly find 450 feet of bedded rock at Cincinnati, almost every foot of which lies open to study within the city limits. The only stratum, however, that admits of easy identification, lies at an elevation of 425 feet above the river, and this accordingly is assumed as the upper limit of the division to which Prof. Orton gave the name Cincinnati beds proper.

The *Platystrophia lynx* horizon at Cincinnati forms the Mount Auburn bed of Nickles (The Geology of Cincinnati, Journal, Cincinnati Soc. Nat. Hist, 1903). If its thickness be estimated at 20 feet, it is evident that the specimens of *Leptaena* must have occurred at least 10 feet above the base of the Arnheim or Warren bed. This estimate is probably too low, but the former presence of the lower part of the Arnheim bed at Cincinnati is certain.

Laptaena rhomboidalis is widely distributed in the Arnheim bed. In Ohio and Indiana it occurs near the middle of the bed, making its first appearance a short distance below the *Dinorthis retrorsa* horizon and continuing to a little above this horizon. It occurs at this horizon along Reser-

voir creek, north of Lebanon, Ohio; also seven miles northeast of Lebanon, on Lick run, opposite the mouth of Caesar creek; along Short creek, below Arnheim, 42 miles southeast of Lebanon; about three miles south of Maysville, Kentucky, along the railroad, and 22 miles south of Arnheim. In Indiana, *Leptaena rhomboidalis* occurs at the *Dinorthis retrorsa* horizon about 40 miles west of Lebanon, and five miles east of Brookville, on Big Cedar creek, a short distance south of the pike to Mount Carmel; also 23 miles south of Brookville, about a mile southeast of Sparta, east of the Sparta fork of Allen branch; 33 miles southwest of Sparta, opposite Madison, along the pike from Milton, Kentucky, to Bedford, at the head of the first gully crossed by the pike, about on the same level as the bridge, about a mile south of the Ohio river; about 20 miles southeast of Madison, about a mile east of Pendleton, Kentucky, on the Louisville and Nashville railroad, at the second railroad cut east of a house on the north side of the railroad. The association of *Leptaena rhomboidalis* with *Dinorthis retrorsa* has not been noted, so far, at any locality south of those mentioned as occurring near Maysville and Pendleton, Kentucky, but this is merely because *Dinorthis retrorsa* has not been detected farther southward. *Leptaena rhomboidalsi* continues to occur at the same horizon at least as far as Lebanon, Kentucky. *Dinorthis retrorsa* is listed by Linney in his Notes on the Rocks from Central Kentucky, published by the Kentucky Geological Survey in 1882; but it is not stated at what locality it was found, although the list presumably includes only fossils from the counties lying between Madison and Marion county. In the Geology of Marion county, by W. T. Knott, and published in 1885, however, the name does not occur.

There is no very good reason for doubting the accuracy of the identification of *Dinorthis retrorsa* from central Kentucky. The fossil has a very characteristic form and should not readily be mistaken. At any rate, *Dinorthis retrorsa* has been found associated with *Leptaena rhomboidalis* as far south as the landing at Clifton, on the Tennessee river, in western Tennessee.

Another fossil having a considerable distribution at the

Dinorthis retrorsa and *Leptaena rhomboidalis* horizon is *Rhynchotrema dentata,* or, at any rate, a scarcely distinguishable variety of this species. It occurs at this horizon at Arnheim, Ohio, and near Maysville, Kentucky. Farther southward, in the absence of *Dinorthis retrorsa,* it may be traced along the same horizon, in association with *Leptaena rhomboidalis.*

Rynchotrema dentata occurs associated with *Leptaena rhomboidalis* at the Brown's run school house, about 8 miles southeast of Maysville, two miles northeast of Rectorville; also 30 miles south of Maysville, at the foot of the hill east of Wyoming; 14 miles southwest of Wyoming, about half a mile southwest of Howard mill, on the road over the hill to Spencer; 13 miles southwest of Howard mill, at the Curry bridge across Howard creek, reached by going a mile south, and then two miles west from Indian Fields. A mile north of the crossing of the Stanford-Rowland pike over Logan creek, at a large exposure on the western side of the creek, *Leptaena rhomboidalis* was found in the upper part of the exposure. *Rhynchotrema dentata* is found associated with *Leptaena rhomboidalis* also a mile and three-quarters west of the court house at Lebanon, Kentucky, near the lower part of a gully located 20 degrees west of north from the home of Col. J. B. Wathen; also 30 miles northwest of Lebanon, half a mile north of High Grove, and about six miles south of Mount Washington.

Leptaena rhomboidalis may be found at many localities at which *Dinorthis retrorsa* and *Rhynchotrema dentata* are absent. This horizon in the Arnheim bed is fairly fossiliferous at all localities in Ohio, Indiana, and Kentucky. On this account it may be traced with confidence entirely around the Ordovician area of Ohio, Indiana, and Kentucky. It promises to be a very valuable horizon for purposes of mapping, especially for those who are not familiar with the bryozoans of this area, the bryozoans, after all, constituting the final authority in the discrimination of Ordovician strata.

Rhynchotrema dentata is found in association with *Leptaena rhomboidalis* and *Dinorthis retrorsa* also at Clifton, Tennessee.

On the eastern side of the Cincinnati geanticline,

Platystrophia lynx is very abundant in the Mount Auburn bed, but along this area it is found also in the Warren bed, usually near the middle of the Arnheim bed, but a short distance beneath the *Dinorthis retrorsa* horizon. In the lower part of Lick run, opposite the mouth of Caesar creek, northeast of Lebanon, Ohio, *Platystrophia lynx* occurs 7 feet below the *Dinorthis retrorsa* horizon. Near Arnheim, Ohio, it occurs about 8 feet below *Dinorthis retrorsa*. At Wyoming, Kentucky, a massive, fine grained, argillaceous, blue limestone underlies the horizon containing *Rhynchotrema dentata* and *Leptaena rhomboidalis*, and at various levels in this rock *Platystrophia lynx* may be found. *Platystrophia lynx* is associated with *Leptaena rhomboidalis* at this horizon at all points farther southward. At some of these, for instance at the locality west of Lebanon, *Platystrophia lynx* occurs both above and below this horizon. On the western side of the Cincinnati geanticline, a few specimens of *Platystrophia lynx* may be found two or three feet above the *Leptaena rhomboidalis* horizon even as far north as the locality along the creek, about a mile south of Mount Washington, in Bullitt county, Kentucky, but farther north no specimens of *Platystrophia lynx* have been detected as yet in the Arnheim bed. As far as may be judged from the evidence at hand, *Platystrophia lynx* after a period of extraordinary development during the Mount Auburn period, was much reduced in numbers and disappeared northward, but continued to exist in southern Kentucky during the deposition of the lower part of the Arnheim bed. During the middle of the Arnheim period it increased in numbers and extended its range northward at least as far as Lick run on the eastern side of the Cincinnati geanticline, but on the western side it has not been found at this level, as yet, north of Mount Washington.

No specimens of *Platystrophia lynx* were found at the *Dinorthis retrorsa* horizon, at Clifton, Tennessee, but at Newsom, about 15 miles southwest of Nashville, a single good specimen was found in association with four specimens of *Rhynchotrema dentata* in what is regarded, provisionally, as equivalent to the Arnheim bed.

Another fossil, whose presence near the middle of the

Arnheim bed is of interest, is *Dalmanella jugosa*. This species occurs in such great numbers in the lower part of the Waynesville bed in most parts of Ohio and Indiana, that this part has been called the *Dalmanella zone*. However, it occurs at some localities also in considerable numbers in the middle and lower part of the Arnheim bed. This is true especially in Franklin county, Indiana. Its range begins at least 10 or 15 feet below the *Dinorthis retrorsa* zone, and extends for several feet above the latter. On the eastern side of the Cincinnati geanticline, at Arnheim, Ohio, *Dalmanella jugosa* is rather abundant in a layer, nine inches thick, also containing *Platystrophia lynx* which is nearly 9 feet below the *Dinorthis retrorsa* horizon. It occurs associated with *Platystrophia lynx*, also at Maysville, Kentucky, eight feet and three inches below the lowest specimens of *Leptaena rhomboidalis* and a greater distance below the *Dinorthis retrorsa* horizon. At most localities, however, *Dalmanella jugosa* rare, or even absent, in the Arnheim bed.

Dalmanella jugosa is found associated with *Dinorthis retrorsa*, *Rhynchotrema dentata*, and *Leptaena rhomboidalis* at Clifton, Tennessee, and is associated with *Platystrophia lynx*, and *Rhynchotrema dentata* at Newsom, in that state.

On going from Maysville, Kentucky, and Madison, Indiana, southward, toward central Kentucky, the lower part of the Richmond is found to become rapidly more argillaceous and less fossiliferous. At the more southern localities, in central Kentucky, there are no specimens of *Streptelasma*, *Protarea*, *Strophomena*, *Leptaena*, *Rhynchotrema capax*, no numerous specimens of *Dalmanella jugosa* present, as in the lower part of the Richmond in Ohio and most of Indiana. A thin zone of bryozoans, several feet thick, is found at the very base of the Richmond, but, for those who do not make a special study of bryozoans, their identification is not easy, and their utilization for determining the boundaries between the Richmond and Maysville or Lorraine divisions of the Cincinnatian becomes impracticable. Hence the great value of the *Dinorthis retrorsa*, *Leptaena rhomboidalis*, *Rhynchotrema dentata* horizon for the aver-

age investigator. With this horizon as a guide, the line between the Richmond and Maysville, determined at a few localities by an expert on bryozoans, may be followed for long distances merely by taking advantage of lithological differences.

Another point of interest in connection with this *Dinorthis retrorsa*, *Rhynchotrema dentata*, and *Leptaena rhomboidalis* zone at the middle of the Arnheim bed is their recurrence in the Waynesville bed. They are found in the upper third of the Waynesville bed in various parts of Union and Franklin counties, Indiana; and *Rhynchotrema dentata* and *Leptaena rhomboidalis*, without the presence of *Dinorthis retrorsa*, are widely distributed at this horizon in Ohio, Indiana, and adjacent Kentucky.

A most interesting case of the recurrence of species has recently been discovered by Dr. George M. Austin at Stony Hollow, north of Todd fork, at Clarksville, southwest of Wilmington, Ohio. Here *Herbertella insculpta* occurs in the Waynesville bed thirty feet below the chief *Herbertella insculpta* horizon which is used to distinguish the Waynesville bed from the Versailles or Middle Richmond bed. *Zygospira kentuckiensis* was found 15 feet below the top of the Waynesville bed, and about 45 feet above the base. East of Pendleton, Kentucky, *Zygospira kentuckiensis* occurs in association with *Tetradium fibratum* and *Calopoecia cribriformis*, 5 feet below the lowest layers containing *Streptelasma rusticum* and *Strophomena planumbona*, and between 40 and 50 feet above the base of the comparatively nonfossiliferous beds which here represent the middle and lower part of the Waynesville bed. The same *Zygospira kentuckiensis* horizon is exposed at the mouth of Bull Creek Clark county, Indiana. Here the lowest layers containing *Dinorthis subquadrata* occur 20 feet above the top of the *Zygospira kentuckiensis* horizon, with *Streptelasma rusticum* *Columnaria halli*, *Strophomena planumbona* and *Rhynchotrema capax* in the intervening rocks. This *Zygospira kentuckiensis* horizon, with the overlying fossiliferous beds may be traced as far southward as Lebanon, Kentucky. It was noticed by Linney in Nelson county, Kentucky (Geology of Nelson county, 1884, page 34). The *Rhynchotrema denta-*

ta and *Leptaena rhomboidalis* mentioned in the same sentence occur much lower, associated with *Platystrophia lynx*, in the Arnheim bed. East of Pendleton, in Henry county, the *Zygospira kentuckiensis* horizon is found 73 feet above the horizon containing *Dinorthis retrorsa* and *Leptaena rhomboidalis*.

EDITORIAL COMMENT.

THE WILLIAMETTE METEORITE.

Mention was made in the current volume of this journal (p. 47) of this wonderful meteorite. Later it was transferred to the "mining building" at the Lewis and Clark Exposition, at Portland, Ore., where it remained till the close of that exposition. As it was being moved into the building the writer made (August 23) the photograph which is reproduced herewith, (plate xiii, fig. 1). Prof. H. A. Ward has published a description of this iron,* with ample illustration, and the accompanying figure 2, of plate xvi, is taken from his publication.

The general shape of the mass is that of a depressed liberty bell somewhat elongated by lateral pressure. The general outline is rounded, there being no angularities except at the edges of the basins or holes that penetrate it, and which occupy a large part of the lower surface. The size of the mass is expressed by the following dimensions:

Extreme length 10 ft. 3½ inches.
Breadth 7 ft.
Hight 4 ft.
Estimated weight, from 12 to 15 tons.

When it was discovered it lay nearly buried in the earth and soil, but a small part of it being visible. On being exhumed it was found to lie with its conical point downward, the reverse of the position shown in fig. 2 of plate xvi. It is probable that in passing through the air in its descent it had that position. The denser part is in the cone and that

* Proc., Rochester Academy of Science, vol. 4, pp. 137-148, March, 1904.

FIG. 1. THE WILLAMETTE METEORITE.
Size: 10 ft. 3½ in. x 7 ft x 4 ft

FIG. 2 THE WILLAMETTE METEORITE
Showing the Concavities on the Lower Surface

part must necessarily have been in advance of the lighter portion, which was that shown now by the lower surface. The lower surface has lost a large portion of its original mass through the removal of such ingredients as once filled the openings. Those ingredients were certainly not metallic iron, but probably such stony matter as is frequently known to accompany sideritic meteorites; although at the present time no trace of such stony matter remains.

The whole surface has lost its original scale, if it had one, and is covered now by a film of iron rust, which, in some of the protected depressions at the base of the conical part, is so thick that it forms a firm scale about a thirty-second part of an inch in thickness. Such scale of iron rust, which must have covered the whole mass rather uniformly originally, and has been rubbed off by the accidents of transportation, indicates the long period of time which has elapsed since the iron reached the earth. It appears to require an oxidation continued through many centuries, and perhaps thousands of years. On the conical part Dr. Ward mentions the occurrence of isolated small protuberances of a slightly darker shade than the main mass. He attributes them to "flows of melted matter which were once more widespread, or continuous;" they would, in that case, be remnants of the fused dark film by which all meteorites are covered when they fall. It might be questioned, however, whether such fused flowage matter would be less or more oxidizable than the mass of the iron. Being non-crystalline it would be reasonable to expect it to be more attackable by the atmosphere, and by moisture in the ground, than the crystalline iron mass, and hence, rather than standing out in prominences it would wholly decay and slough off before the iron could be reached. The writer noticed these darker patches, which average from half to three-quarters of an inch across, and on the spot assumed that they are due to inequalities in the iron, or to the occurrence of some ingredient less oxidizable than the iron by which they are surrounded. They do not appear to be composed of troilite nor of any silicate, and the the occurrence of diamonds of that size, while possible, is perhaps too bold a suggestion to be entertained.

The flange, or rim, of the meteorite presents characters very remarkable and different from the conical part. Here can be seen those surface pittings which are common on meteorites. They are coarse, sometimes reaching more than an inch in diameter. They can be seen on the plate (xiii) at the lower left hand corner of figure 1 and less distinctly at the right hand lower corner and uniformly over the lower surface in figure 2. So far as the writer observed there is here no remnant of the "black crust," but the depressions are covered with a later-formed crust of iron rust. This rusting, however, appears to have been less intense than on the cone. The film is not so thick and the pittings themselves are not destroyed. This difference may be due to the fact that the upper surface, as it lay in the ground, was less continuously wet, and may have stood for many years some inches above the surface of the soil. These surface pittings do not appear in the basins and holes that characterize the lower surface of the meteorite, but the interior surfaces of those basins are marked by larger, irregular swellings and branches that resemble, in shape the irregularities which mark the outlines of these basins at their intersection with the general surface. This curious appearance is illustrated by fig. 2, plate xvi, where, by a conceit of the photographer, two children are seen resting in the concavities.

It is only by reference to the photograph copied from Dr. Ward's description, that one can get a correct idea of these most singular concavities. They swell out so as to come into union with each other, or almost into contact, separated only by thin partitions of the metallic iron of the mass. The iron which separates these basins along such partitions, leaves on breaking down, or rusting away, sharp edges and little buttresses. Some of the depressions are small, not more than an inch in diameter. They all come to sharp edges where they intersect the pitted surface, and almost without exception they are larger at some depth from the surface than at the surface. The smaller ones appear not only in the main metallic mass, near the base of the conical part, but most abundantly throughout the iron that encloses the large concavities. Some of these smaller openings are elongated like auger holes, and some of them pass

quite through the flange, being a foot or more in length and only an inch or two in diameter. From these elongated holes there are all stages of gradation to the shallower and larger basins, indicating a common nature and origin.

Dr. Ward makes a distinction between the channels and basins on the two sides (the upper and the lower) of the iron mass. Those on the conical side (the brustseite) are attributed by him to atmospheric pressure and friction. Those which cross the outer edge of the great flange, cutting channels across its outline, he likewise ascribes to the action of the compressed air and the heat resulting from the passage of the mass through the atmosphere, while those which are wholly confined to the lower surface, not penetrating deep enough to reach the brustseite, nor extending laterally far enough to reach the outer edge of the flange, he attributes to atmospheric decomposition of the iron since it fell, aided by the moist soil and the carbonic acid resulting from vegetable decay.

The parties having the meteorite in charge at the Lewis and Clark Exposition, attached a label which read as follows, evidently derived from Dr. Ward's paper:

"When this meteorite was discovered it was imbedded in the earth, the base uppermost, the position which it probably held when it fell through our atmosphere, centuries ago. The pitting, hollowings, and channelings observed on the surface are due to the heat caused by the compression of the air."

We are compelled to take sharp issue with Dr. Ward as to the origin of these features. We did not notice any of those differences which he mentions, and most of the hypothetical operations of the air appear to be problematical or impossible, so far as applicable to this meteorite. We cannot understand how the air can bore auger holes into an iron meteroite, and that too in various directions. Some of these small excavations are directed parallel (or approximately so) to the supposed direction of flight; others are nearly at right angles to it. They also branch or anastomose with others. They appeared to the writer to grade, as to form and position in the iron mass, into each other, and to differ only because of the form and position of some different ingredient which once occupied the cavities. It is to the writer very questionable whether any meteorite, in

passing through the atmosphere, becomes heated to the depth of any, even the shallowest, of these cavities. When the Winnebago meteorite fell, one of the three large masses struck in a meadow where the dried long grass was carried by it into the earth. On being exhumed the dry grass had not been consumed, nor charred, but adhered to the meteorite when it was taken out. Another small piece fell on a straw stack but did not set it on fire. This goes to show that the heat experienced by a meteorite when it falls is but momentary, and affects only the surface. It is intense, and fuses the matter of the meteorite superficially forming a glassy "black crust" which is well known; and it goes also to show that such channels and furrows as observed on the Willamette meteorite can scarcely be attributed to heat and friction of the air at the time of the fall. It is difficult to understand why, if these phenomena be due to the heat and friction of compressed air during the passage of the mass through the air, they are confined to the rear surfaces of the mass. It would be reasonable to expect to see the effect of compressed air at the point of greatest compression, i. e., the front side of the mass, but they are entirely wanting on the front. They are most abundant on the rear flat surface.

Again it is difficult to understand why an iron mass should be corroded and rusted out, in the manner assumed by Dr. Ward, by atmospheric air and water after it fell. He assumes that initial rusting points extended themselves so as to form basins and cavities such as seen on the base of this meteorite, the carbonated water once gathered in the depression having eaten into the iron deeper and deeper, expanding its basin on all sides as it goes down. It would be germane to inquire, under that hypothesis. (1) Why the depressions, were not filled with iron rust instead of soil when they were discovered? (2) If the mass was uniform iron, as presumed by this hypothesis, why was it not uniformly rusted all over the surface, even the upper (originally upper) surface which was slightly "crowning" so as to shed water? (3) Why was the edge of the flange eaten into, and even cut entirely through from top to bottom in a few places and not on all sides evenly? (4) Why were those cavities and channels which open on the conical surface and do not

reach the bottom surface rusted out in that way? The acidulated waters could not have been retained in them, being bottom side up. (5) How could the "pittings" on the bottom surface be preserved while the waters with which they must have been brought into contact were eating such enormous cavities in the immediate and contacting iron.* (6) why are the bottoms of these basins always basin-shaped, curving from the sides regularly inward instead of being flat and the sides expanded outwardly to the very bottom?

We prefer to consider all these cavities as due simply to the vacancies left after the removal of other minerals, such as troilite, olivine, enstatite and perhaps other silicates. It is but fair to Dr. Ward to state that he recognizes this possible cause for these cavities. But he plainly does not approve it, since he dwells on the causes discussed by him at length and only mentions this as a possible alternative. Again, the agent of removal of such stony matter he implies was heat and friction at the time of the fall, these materials being considered by him as "softer and more easily yielding to attrition."

On the other hand these cavities have probably all been formed since the meteorite fell, and the manner of removal of the minerals that formerly filled them was oxidation and solution. The shape of these cavities is characteristic. In the association of metallic iron with the usual meteoric silicates the iron usually presents concave surfaces toward the minerals. These concave surfaces come into contact with the convex surfaces of the masses of stony matter. The iron is cellular or spongy with roundish cavities, and runs to points and edges. It appears to have taken shape after the other minerals, or in obedience to the crystalline demands of the other minerals. This is well exemplified by the Kiowa meteorite which was illustrated by the writer in 1890,* and the writer has observed no exception to that rule.

* The writer saw, many years ago, a slab of Corniferous limestone which had been drawn up from the bottom of lake Huron by fishermen on their nets in the vicinity of Thunder bay, Michigan, which had been corroded by supposed acid waters that entered the lake at invisible springs in the bottom of the lake. Its surface was completely covered with small basin-shaped depressions about 1¼ inch in depth and from 1 to 2 inches in diameter, but there was no portion of the original surface remaining.

* AMERICAN GEOLOGIST, May and December, 1890, vols. 6 and 7.

The cavities in the Willamette meteorite are in accord with it.

Further, the minerals that form the stony parts of iron meteorites (and the same is true of stony meteorites) are particularly susceptible to oxidation and total decay. That is probably the reason that by far the larger number of meteorites which have been found, without any knowledge of the date of their falling, are irony meteorites, while by far the larger number of those which have been seen to fall are stony meteorites. If this ratio has prevailed throughout past ages, it argues that the stony meteorites have rotted. It has even been suggested that all or many of the irony meteorites that have been found are merely the irony remnants of former stony meteorites which have otherwise rotted and been converted into soil. The mineral olivine is one of the most easily changed silicates, a fact familiar to all petrographers. It has contributed largely toward the serpentinous greenstones. Its easy decay loosens and promotes the alteration of the other associated minerals. It is a very abundant mineral in nearly all irony meteorites. Troilite is a sulphide of iron. It is easily oxidized, and gives rise to sulphuric acid which powerfully attacks everything adjacent. We do not know what were the minerals that originally filled these cavities, but that they embraced both olivine and troilite is highly probable. Microscopic examination, according to Mr. H. L. Preston (quoted by Dr. Ward), discloses that "there are numerous small troilite nodules from one to three millimetres in size scattered promiscuously throughout the section; and a few rod-shaped ones one millimetre in width and in some instances up to fifteen millimetres in length. The largest troilite nodule found in several sections was twenty-eight millimetres in diameter." This strongly indicates that one of the chief minerals originally in these cavities was trolite, and it may have been the only mineral.

If this explanation of these cavities be correct, it is reasonable to expect that in case a meridional section of the mass is ever made it will disclose some large roundish masses of troilite, which is very likely to be associated with some silicate minerals.

The "furrows" that appear on the brustseite which are referred by Dr. Ward to the heat and friction of the atmosphere, are generally shallower than those on the lower surface. There is no question that such a mass of iron in falling through the atmosphere would lose a considerable amount of its surface by heat and friction. The brilliant trail which is well known to mark the course of a meteorite in falling through the air attests the loss of matter from the meteorite. But it would be very singular if, during the short interval of time occupied by the descent, the air should make such selective "gougings" as are seen on this meteorite.

We cannot perhaps satisfactorily account for the shallower forms of the depressions referred by Dr. Ward to atmospheric pressure and heat seen on the upper side of the iron; but it seems to the writer that they were also once occupied by the same minerals as above mentioned, and that an earlier period in the history of the mass had worn them down or cut them off uniformly with the surface of the iron so that when they entered the earth's atmosphere these depressions in the iron surface existed but were filled with smaller remnants of the stony matter. It is useless to inquire into the earlier history of this mass, but it must be admitted that it parted from some mass like itself, and its troilite masses must have been rent asunder whenever the plane of separation crossed them. Thus some of the troilites at the present surface may have been shallower than others. Further these shallow depressions are not confined to the brustseite, nor the deep ones to the rear surface. If they were thus distributed there would be more force in Dr. Ward's assumption.

It is needless to say that this iron constituted the most wonderful single object in the mining building. It is the largest meteorite ever found in the United States, and according to Dr. Ward the fourth largest known to science. We cannot but sympathize with those Oregon scientists who wish to have it remain in the state of Oregon, rather than see it transported to some eastern museum.

N. H. W.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

A preliminary list of mastodon amd mammoth remains in Illinois and Iowa. NETTA C. ANDERSON.

On the proboscidean fossils of the Pleistocene deposits in Illinois and Iowa. JOHAN AUGUST UDDEN.

(Augustana Library Publications. No. 5. Rock Island,, Ill. 1905.)

These papers constitute an important addition to the literature of Pleistocene geology. Miss Anderson has gathered the data, so far as the same can be ascertained, concerning all the known instances of the discovery of the remains of these extinct animals in the states of Illinois and Iowa, culling from geological reports and other publications, and from museums and curators such facts as have not been published. The total number of finds is over eighty. Two outline county maps of these states show the geographic distribution of these remains, from which it appears that the mastodon and mammoth ranged throughout these states. In Illinois the localities are rather evenly scattered, but in Iowa they are far more numerous in the southeastern part of the state, usually prevailing along the main river valleys. In the southwestern part of Iowa also is a grouping, suggesting some relation to the great valley of the Missouri river.

These eighty odd finds are discussed by Prof. Udden from four points of view, viz: (1) Conditions of interment; (2) Specific determination; (3) Relation to different drifts; (4) association with other fossils.

In relation to the method and conditions of interment Prof. Udden makes the broad statement, "that the greater number of the animals whose remains have been discovered perished in low and boggy localities, sometimes probably in search for water or salt. These remains have come from stream beds and alluvial deposits, and from terrace and glacial gravels. But most of the fossils have come from the loess or from near the surface of the boulder clay under the loess." Prof. Udden gives the following table of conditions of interment:

SPECIMENS FOUND IN	Number consisting of two or more parts of a skeleton.	Number consisting of single teeth or bones.
Streams or in alluvium	2	17
Glacial gravels	1	4
Bogs or near springs	17	1
Loess or on Glacial clays	23	1

As to the specific identification, the following have been expressly identified: Mastodon, Elephas primigenius and Elephas americanus, the first mentioned probably being Mastodon americanus, of which 39 individuals are listed.

The relations these fossils bear to the different parts of the drift sheet as more recently subdivided by the Iowa geologists is plainly one of great interest. Many of the observations were made before the different parts of the drift had been recognized, "and some were even made by geologists who did not regard land ice as necessarily an agent in the deposition of the glacial till." Barring all the uncertainties and imperfections of the record of the data discussed the author still reaches some valuable and interesting conclusions. These conclusions are tabulated below.

AGE	Teeth or tusks only	Bones, mostly with teeth or tusks.
Specimens of unknown age.		
Mammoth	9	....
Elephas primigenius	2	....
Elephant	7	....
Mastodon	13	2
Undetermined	....	1
Specimens of the pre-Kansan (?) or Kansan (?) age.		
Mastodon	....	1
Specimens from the ferretto zone, post-Kansan and pre-loessian.		
Mastodon	....	4
Specimens from the surface of the Illinoian drift, post-Illinoian and pre-loessian.		
Undetermined	1	1
Specimens from the base of the loess, post-Kansan and pre-Iowan.		
Elephant	....	2
Mammoth	....	2
Mastodon	1	....
Undetermined	....	1
Specimens from the loess.		
Elephas americanus	....	1
Mammoth	....	2
Undetermined	....	1
From the area of the Iowan drift, post-Iowan.		
Mammoth	....	1
Mastodon	1	....

AGE	Teeth or tusks only	Bones, mostly with teeth or tusks.
From the area of the Wisconsin drift, post-Wisconsin.		
Elephas primigenius	1	....
Elephant	....	1
Mammoth	1	2
Mastodon	2	4
Undetermined	....	1
From alluvium, mostly sub-recent, but some, perhaps, older.		
Elephas primigenius	....	1
Mammoth	....	2
Mastodon	....	10
Undetermined	....	4

Associated with these mastodon and mammoth fossils have been found also the bones of the buffalo, wolf, peccary deer and elk; also the "land shells Helicina, Succinea, Pryamidula, Bifidaria, Limnæa and others which are characteristic of the loess." "In Rock Island the loess which contained elephant bones also contained fragments of coniferous wood, and at Davenport, in Iowa, the peaty loess from which tusks and other bones were taken has a seam of diatomaceous earth, in which no less than thirty-three now living species of diatoms have been identified."

The discovery of these land mammal fossils in the loess which contains the land shells so often appealed to by those who adopt the æolian theory of the origin of the loess in the Mississippi valley, adds so much more of the same kind of evidence to the support of that theory. It is only necessary to assume that the wind storms that buried the land shells in wind-blown dust and sand were, say, ten thousand times more violent and dust-laden than has been supposed, and that the great land animals that coexisted with the snails were overwhelmed at the same time. And, further, the winds must have been violent enough to rend apart their carcases and to scatter the bones of their skeletons for considerable distances asunder, even extracting the teeth from their sockets. It is a much more natural and simple matter to get the wind-blown dust and the laminated loess into superposition above these fossils than to get the fossils below considerable thicknesses of the laminated loess. The æolian hypothesis accomplishes this in a most admirable and satisfactory manner.

From the foregoing table it is learned that the mastodon and the mammoth existed, perhaps, prior to the Kansan ice epoch, and continued into the Iowan epoch, into the Wisconsin and even into

the sub-recent, having become extinct perhaps not more than five thousand years ago.

As to man and the elephants, these data give no direct testimony that they were cotemporary, except in one instance. Mr. M. T. Myers, of Fort Madison, reports the finding of "one human leg bone and one flint arrow head" associated with the remains of the mammoth in the alluvium of Lee county, Iowa. This is in the region where so-called "elephant pipes" have been claimed to occur in mounds constructed by earlier inhabitants of the country. "At all events the evident recency of some of the proboscidean remains makes us expectant of some fortunate discovery giving conclusive proof that man lived on this continent while these huge mammals were yet here." N. H W.

Indiana Department of Geology and Natural Resources. 29th Annual Report. W. S BLATCHLEY, State Geologist, pp. 1-888; pl., 34; figs., 67; maps, 7; Indianapolis, 1905.

In the introduction to this report Prof. Blatchley reviews the development of the natural resources of the state during the past ten years. During 1895 the total output of coal, oil, gas, building stone, clay-products and portland cement was $16,770,816, while in 1904 the total output of these same products was $36,028,755, or an increase of 115 per cent.

The body of the book is made up of an article on "The Clays and Clay Industries of Indiana" by W. S. Blatchley. In the opening chapter he treats of the technology of clay. The geological distribution of Indiana clays forms the subject of the second chapter which is followed by "The Clays of Indiana by Counties" in which the clays within five miles of transportation lines are taken up and discussed in detail. Analyses are given and suggestions made as to the possible utility of individual deposits. These are frequently accompanied by maps and halftones of the exposures. In the fourth chapter, the clay working industries of Indiana, he discusses the growth of the clay-working industries of the state from $3,858,350 in 1900, to $6,085,242 in 1904, and gives in detail the methods and processes of manufacture, tests and uses of the products made from Indiana clays. These include paving material, sewer pipe and hollow wares, refractory products, pottery and allied products, dry pressed brick, structural terra cotta, building brick and tile and the production of clay for shipment. This article is calculated to be a practical aid to the development of the clay resources of the state and, while a larger number of maps would have added to its value, yet, it serves that end admirably. It is intended largely for the use of the layman and is couched in the clear simple language characteristic of the author.

The remaining quarter of the book contains five articles, the first of which is the report of the mine inspector, James Epperson. This shows the total output of coal for 1904 to be 9,872,404 tons against 9,992,553 tons for 1903. The next article is the report of

the gas inspector, Bryce A. Kinney, which is followed by a short article by Prof. Blatchley on the utilization of convict labor in the making of road material. The petroleum industry of Indiana, by Blatchley, concludes the geological part of the book. He states that "The output for 1904 was greater than in any previous year, both in the number of barrels produced and in value, though the average market price declined nearly seven cents. Since 1898 each year has seen an increase in production, and in the seven years has more than trebled." The most important development during the year was in the Munsie-Parker-Selma field where a third "pay streak" was discovered 240 to 300 feet below the top of the Trenton rock at this place. The output for 1904 was 11,330,030 barrels valued at $12,127,107. The last article is by Melville T. Cook on the "Insect galls of Indiana." J. W. B.

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CORRESPONDENCE

ECONOMIC GEOLOGY IN PERU.—It might be of some interest to the readers of the AMERICAN GEOLOGIST to learn something about the scientific organization recently created by the government of Peru to investigate the natural resources of the republic. Owing to the very rapid development of the various mining industries, the establishment of a bureau which should be authorized by the government to locate and fix boundaries of mining claims, collect statistics relative to the production and values of ores, and accumulate various data relative to the geology, mineralogy, and geography of the country, became an immediate necessity. Accordingly in 1902 the bureau now known as the "Cuerpo de Ingenieros de Minas del Peru" was established with Sr. J. Balta, the present minister of public works, as the director. It was soon discovered however, that the subjects and projects demanding the immediate and serious consideration of this organization were so numerous and varied in kind, that it became highly advisable to classify the work in hand and distribute allied lines of investigation to independent commissions each with its chief and corp of assistants, the series of commissions, however, being under the general charge of the Director of the "Cuèrpo," Sr. Marco A. Denegeri. The divisions of the "Cuerpo" are as follows:

1. Division of Mines, established 1902, including:
   - (a) *Permanent* commissions in large mining areas, to locate claims, fix boundaries, etc.
   - (b) *Exploratory* commissions to investigate and report upon newly discovered mining areas.
2. Division of Water Supply, established 1904, including:
   - (a) *Engineering* projects relating to the storage and distribution of surface water for irrigation purposes.
   - (b) *Geological Investigations* to determine location and distribution of underground waters.
3. Division of Economic Geology, established in 1904.

All these commissions have their responsible chiefs and one or more assistants and among these chiefs are four American specialists, namely, Dr. George T. Adams, in charge of underground waters, M. H. Hurd and Chas. W. Sutton for engineering and topographic work, and Mr. V. F. Marsters for economic geology. The only non-Peruvian technical assistant is Mr. H. T. Stiles, who is under the direction of Mr. Hurd. At this time there are at work:

2 Permanent mining commissions.
6 Exploratory mining commissions.
1 Economic geology commission.
2 Topographic and water-supply commissions.
1 Underground water commission.

Generally the names of the permanent commissions are taken from the districts in which they are located, e. g., the Cerro de Pasco, Yauli Ica, Callao, etc. commissions. Each commission is allowed a certain sum of money which is under the direct control of the responsible chief.

The object of the geological commission is to investigate specific problems relative to the development of the metallic and non metallic deposits of Peru. This department constitutes the first official geological survey in the republic. The first problem to be considered will be the geology of the oil fields of northern Peru (Province of Tumbes.)

While the "Cuerpo" has been in existence but a little over three years some twenty-six bulletins dealing with a wide range of subjects have been published. These may be obtained by application to the Director, Sr. Denegeri.

Lima, Peru, Sept. 12, 1905. V. F MARSTERS

MATEO TEPEE —A little over a year ago, while going over several new works, the writer was struck by the many ways in which the several authors had in spelling the same words. Several instances were noted, but one of the best illustrations was that of a volcanic tower in the northeastern corner of Wyoming—"Mateo Tepee," or what is more popularly known as the "Devil's Tower." This tower of perpendicular basaltic columns, may be seen to the right of the Burlington railroad in going west, between New Castle and Sheridan, Wyoming. According to Newton and Jenney, it has an elevation of 625 feet from the surrounding country and may be seen for many miles around.

Professors Chamberlin and Salisbury spell it in their new Geology, page 136, fig. 124, "Matteo Tepee," locality Wyoming.

Prof. R. S. Tarr, spells it, in his "New Physical Geography," fig 231, facing page 127, "Mato Tepee" locality Wyoming.

In the May number 1904, of the AMERICAN GEOLOGIST, under the title of "Editorial Comment, Peleliths," plate 22 facing page 324, the same name is spelled "Mato Teepee" and the locality given as South Dakota.

In the "Report on the Geology and Resources of the Black Hills

of Dakota" by Henry Newton and Walter P. Jenney, 1875, published 1889, it is spelled again Mato Teepee and the locality given as Dakota—i. e. one would infer as much from the title of the report. However, a map of the Black Hills was prepared by these gentlemen and accompanies the report, and shows the tower to be in Wyoming. At the time this report was made the tower was called "The Bad God's Tower" or in other words "The Devil's Tower."

The boundary line between South Dakota and Wyoming is a little west of 104° or about 104°-1′-30″. "Mateo Tepee" or "Bear Lodge" as Newton and Jenney called it, is located on their map at almost exactly 104° 45′ W. Long. and 44° 35′ N. Latitude. This places it in the northeast corner of Wyoming, in Crook county.

The name, "Mateo Tepee," is of course of Indian origin, probably from the Sioux, and literally means "Bear Wigwam"—Mäteo, pronounced Mäh-to—meaning bear and " Tepee" meaning wigwam, lodge, or a conical tent. In former days this region (around the Devil's Tower) was a g reat bear country and was visited each year by the Indian bear hunters—hence the name.

In conclusion the writer believes this name should be spelled "Mateo Tepee" and the locality is without a doubt in Wyoming.

J P Rowe

University of Montana, Missoula,
September 21, 1905.

PERSONAL AND SCIENTIFIC NEWS.

Illinois Geological Survey. At the last session of the legislature a bill was passed establishing a geological survey of the state and making an appropriation of $25,000 per year for this purpose. Of this amount $10,000 may, at the discretion of the board of control, be used for topographic mapping in cooperation with the U. S. Geological Survey. This cooperative work has been undertaken for the present year, at least, and work along this line was begun about the first of June. The board of control consists of the governor of the state, the president of the State University and one other member to be appointed by the governor. Gov. Deneen this summer appointed as the third member of the board Prof. T. C. Chamberlin. The headquarters of the survey are to be at the State University at Champaign and the University furnishes rooms for the survey. For printing, etc. $5,000 is available from the state printing funds. Dr. H. Foster Bain, of the U. S. Geological Survey has accepted the position of state geologist and enters upon this work November 1st.

UNIVERSITY OF WISCONSIN. During the coming January Mr. Bailey Willis, of the United States Geological Survey and Carnegie Institution, will present a course of twelve lectures in the Geological Department of the University of Wisconsin on the subject of "Continental variations, with special reference to North America." The course is given primarily for students making geology a major study, and is open to such students not regularly registered at this university.

IN THE YEAR 1904 THERE WERE OBSERVED in Norway 35 earthquakes, of which the most severe was on the 23rd of October, and more than half of the whole number occurred after that date.—Kolderup.

DR. U S. GRANT RETURNED from Alaska, passing through Minneapolis in the early part of September, in time to resume his work at Northwestern University.

DR. W. J. McGEE HAS BEEN APPOINTED DIRECTOR of the Public Museum at St. Louis.

THE LAKE SUPERIOR MINING INSTITUTE will hold its eleventh annual meeting on the Menominee range at Ishpeming, Mich., October 17, 18 and 19. There will be trips by train to Crystal Falls, Iron Mountain, Escanaba and Gladstone.

PROF. CHARLES SCHUCHERT of Yale University, has returned from a geological trip extending over the ancient formations of Nova Scotia, New Brunswick and eastern Quebec.

E. H. SELLARDS late of the University of Kansas, is in charge of the departments of zoology and geology at the University of the state of Florida.

W. J. MILLER HAS BEEN APPOINTED to succeed professor C. H. Smyth Jr, in geology, at Hamilton college, and M. W. Twitchell has been appointed to the chair of geology at South Carolina college, Columbia, S. C.

PROF. C. N. GOULD of the University of Oklahoma, will be absent the current college year and his duties will be discharged by Prof. E. G. Woodruff.

CHARLES W. BROWN has been appointed instructor in geology and mineralogy at Brown University.

Quarry in a Glacially Transported Mass of Chalk, near Malmö, in Southern Sweden.

[Photograph by Dr. N. O. Holst.]

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GLACIAL MOVEMENTS IN SOUTHERN SWEDEN.

By PROF. G. FREDERICK WRIGHT, Oberlin, Ohio.

PLATE XIV.

Having had the privilege of spending two or three days with Dr. N. O. Holst, while he was engaged in surveying for the geological map of Skane, the southern province of Sweden, I am permitted to bring before the English public some of the important and remarkable discoveries which he has made. These relate first to the direction and force of the ice movement, and secondly to the unity of the period.

Skane, the most fertile province of Sweden, projects southward of the main peninsula so as to make it almost a part of Denmark, to which by virtue of its physical geography it properly belongs. It is completely covered with glacial deposits to a depth of 100 or 200 feet. A very well defined terminal moraine runs across the province east and west, about midway between the north and south boundaries.

The material in this moraine is to a considerable extent derived from Finland, showing that the center of glacial dispersion was somewhat farther east in Scandinavia than has been supposed. Both the direction of the moraine and the material of which it is constituted show that in southern Skane the final ice movement had a northwesterly direction. That is, the ice, after moving down the axis of the Baltic sea in a southwesterly direction, when it passed the low mountains bordering the northeastern part of Skane, must have found the line of least resistance in the direction of the North sea, causing it to turn around towards the north,

as the lake Erie ice is known to have done in southern Michigan and northern Indiana.

The most striking indication of this is found in the position of an immense mass of chalk which is included in the moraine about five miles east of Malmö. This chalk mass extends three miles in a northeast and southwest direction, averages 1,000 feet in width, and from 100 to 200 feet in thickness, being, so far as I know, the largest boulder, or glacially transported mass, that has been described. It is everywhere covered with till, and almost everywhere has till underneath it. Its regular position is between what we should call the upper and the lower till, the upper till being yellow and the lower blue. But in one place, which I examined, the lower or blue till was both above and below it.

While the chalk is together in one mass, it everywhere shows signs of immense pressure and disturbance, being broken up into small cubes, and having its flint nodules cracked and arranged in lines simulating stratification. The upper part of the chalk has also been extensively sheared off and mingled with the till.

This mass of chalk has been brought fully to light through its commercial value, eight or ten companies having mined or quarried it for many years. It belongs to the true soft chalk of Cretaceous age, and was supposed by the earlier geologists to indicate a Cretaceous area, where it was least to be expected, since the chalk which mainly underlies the peninsula belongs to the Trias or Lias. The determination of its glacial transportation has therefore solved a very difficult problem. It must have been picked up bodily from the shores or bed of the Baltic sea, being transferred westward many miles to its present position.

Dr. Holst is bringing to light much new evidence bearing upon the unity of the Glacial period, and is more than ever confirmed in his adhesion to the theory that the upper till and the lower till are of the same age,—the lower till being that which was dragg d along under the ice, and the upper till the material which was incorporated in the ice, and which so became oxidized in the process of transmission and deposition. In many cases which he showed me, this would certainly appear to be the fact, as indicated

by the sharp line which separates the blue from the yellow till.

But the most important discoveries bearing upon this point were found at Tapplelargo, twelve miles east from Malmö. Here is an area of several acres covered with an overwash deposit from the moraine, which is a mile or more to the south. In a stratum of clay, about seven feet thick, many species of shells and plants are found, indicating peculiar conditions which can be accounted for only by supposing that during the final melting away of the ice the summers became very warm, so as to allow temperate species to flourish close up to the ice-front, thus allowing them to mingle with arctic or subarctic species.

It is evident from inspection of the stratum that these species lived and were deposited contemporaneously, and not by an advance of the ice after an interglacial period. This would seem to meet the case of comingling of temperate and subarctic species which Coleman has described in the vicinity of Toronto, and so it will greatly simplify our interpretation of glacial phenomena in the northern United States and Canada.

BOLSON PLAINS OF THE SOUTHWEST.

By W. G. Tight, Albuquerque, N. M.

There seems to be a very decided tendency on the part of students in physiographic geology to enlarge upon the conceptions of topographic types, as they are originally described, and in the subsequent study of the topographic features of any particular section, to describe those features in terms of the modified conception of the type forms.

As a result there develops a very confused idea in the minds of workers concerning the true type, and with that misconception in mind the correct interpretation of any particular region becomes doubtful, and the description of that region almost wholly unintelligible, giving to the student who has access to the literature alone, a radical misconception of the true topographic conditions.

As an example of my meaning the term "peneplain" may be taken. It would be interesting to know how many times

an aggradation plain of some sort has been mistaken for a degradation plain and called a peneplain. There are undoubtedly many cases where the two types of plains look nearly alike and only a careful study would determine the true character.

This superficial resemblance, which extends to various types of topographic forms, is a constant source of error. The most serious mistakes are made when two types of radically different origin and structure are classed together and made the basis for broad generalizations.

When an author has described a certain type of topographic form, presumably from a careful study of some definite region, and has given a name to that type, it can only lead to much confusion and error when the same name is used by another to describe a different form, or to attempt to modify the meaning of the term to fit other conditions.

It is not intended at the present writing to discuss the uses and abuses of he term "bolson" as applied to intermontane valleys but rather to take the term as originally described* and apply it to the study of the great valleys of the southwest and especially to New Mexico.

To quote briefly: "Bolsons are generally floored with loose, unconsolidated sediments derived from the higher peripheral regions. Along the margins of these plains are talus hills and fans of boulders, and other wash-deposits brought down by mountain freshets. The sediments of some of the bolsons may be of lacustral origin." "The bolson plains on the other hand," (as distinguished from plateau plains) "are newer and later topographic features, consisting of structural valleys between mountains or plateau plains, which have been partially filled with debris derived from the adjacent eminences." "The bolson plains are constructional detritus plains filling old structure troughs."

It seems that this description is clear enough. The type form is not dependent upon the characters of the bordering mountains nor the character or structure of the deeper valley floor, nor is it especially concerned with the total thickness of the wash-deposits over the floor of the

*HILL, Top. Atlas, U. S., folio 3, p. 8, 1900.

older valley, except in so far as these deposits must contribute an important factor in determining the characteristics of the topography. An important element in this definition depends upon the interpretation of the word "plain." A bolson is genetically related to other constructural plains, such as flood plains and terrace plains of river valleys. In the flood plain and terrace plain deposits the plains are more or less narrow and parallel with the stream, which furnishes the major portion of the deposits. On the other hand in the bolson, while the deposits are of fluviatile origin (or largely so) the plain loses the characters of a flood plain or terrace plain in that it is generally much broader and the material "is derived from adjacent eminences," and the plain is of such an extent that the "talus hills and fan cones and wash-deposits brought down by the mountain freshets" form only the bordering characters of the plain, but point unmistakably to the origin of much of the deposits forming the floor of the bolson.

If we look for a moment at the forces involved in the formation of a bolson we see that there must exist an extensive trough in which the contribution of material from the sides of the bordering mountains is much greater than the capacity of the pre-existing drainage to remove, or that in the structural formation of the valley there is formed a closed basin and into this the lateral materials are deposited. In the closed basin type, the basin may or may not be the location of a lake. If the older trough has free drainage to start with the lateral introduction of debris may be such as to divide an otherwise continuous stream course into a series of lake basins or to even totally obliterate the through-flowing stream as a surface feature.

Mr. Hill says: "These plains or 'basins' as they are sometimes called are largely structural in origin," and again he uses the terms "structural valleys between mountains and plateau plains." If it were intended to confine the term bolson to those forms which occur in strictly structural valleys which have not been subsequently modified by erosion, it would have a very limited use indeed, for but few valleys of that type are to be found, and the author's illustrations do not indicate this limited use. But I take it

that the term "structural valley" or "structural trough" was used in reference to the large features of the topography as distinguished from simply valleys of erosion cut mainly by stream action. The very essential feature of a bolson is that the plain is bordered by mountain forms or plateau escarpments. The mountains may be of the fold or fault type, but rising as they do above the general level of the plateau upon which they stand the intervening area might properly be considered a structural valley. In some cases this intervening area may be so protected from erosion by the distribution of the mountain uplifts that it will be preserved and will present the structural characters of the original plateau plains. Again it may be in the line of the great longitudinal drainage lines of the plateau and be largely removed by subsequent erosion. As far as the later formation of a bolson is concerned, it would appear that either type might properly be called a structural valley, and with the later deposition of the detritus forming the bolson plain, there would be a striking difference in the thickness of the deposits, those in the eroded structural valley being much thicker.

It would appear also that in the formation of such a structural valley by the enclosure of a portion of a plateau by the elevation of bordering mountains, where the valley is not subjected to subsequent erosion and the remaining valley floor is fairly horizontal, there would be produced a topographic form which would resemble very closely the bolson but which would be as essentially different from it as an aggradation plain is different from a peneplain. These two forms having similar superficial characters may be easily mistaken, the one for the other, for with the elevation of the bordering mountains enclosing a structural valley free from erosion, there will most certainly develop around the margin of the remnant of the enclosed plateau plain, talus hills and fan cones and frontal wash aprons which will rapidly work out over the floor of the valley and eventually convert it into a bolson plain while the superficial characteristics may remain almost the same during the entire process.

It is apparent that when the filling of the valley takes

place over the floor of the great structural valley, the production of the bolson does not materially modify the topographic features, but when the great structural valley has been deeply eroded and then subsequently filled the production of the bolson does make a decided difference in the topographic relations of valley and mountains. We see then, that the bolson plain finds its proper place in the series of constructional plains derived from fluviatile actions, and the lowest member of the series is represented by the flood plain of the river, in which the material is almost wholly derived from the longitudinal action of the stream; while the bolson plains are at the opposite end of the series, in which the longitudinal stream may contribute largely in some stages of the building of the plain but that the predominant factor is the derivation of material from the bordering hights by torrential action of temporary streams and rivulets which are produced largely by rainfall.

This in general is the writer's understanding of the use of the term bolson, as applied to many of the great intermontané plains of the southwestern plateau and great basin region. Whether the writer is correct or not in his interpretation of the use of this term, it is certain that under any definition of the term there is found in this region a large number of valley plains having very diverse characters and very diverse origins. The writer cannot therefore agree with Dr. Chas. R. Keyes of Socorro, in his discussion of the bolson plains of New Mexico in the AMERICAN GEOLOGIST for September, 1904. Dr. Keyes has grouped under this term such plains as the Jornada del Muerto, San Augustine, Estancia, Mimbers and the great plains along the Rio Grande, Rio Pecos and Canadian rivers. He has seemed to correlate these plains, with others, with the great Llano Estacada of Texas and other great plains to the southwest. If Dr. Keyes' correlations are correct, it does not seem to the writer that these great intermontane plains of the New Mexico region can be by any definition classed as bolson plains and many of them certainly conform to that definition. In view of this difference of opinion it seems advisable to call attention to some of the features of some of these various plains in detail. It is well understood that the

great stake plains of Texas are made up largely of Cretaceous sediments which have a more or less regular dip from the frontal ranges of the Rocky mountains to the gulf of Mexico. Toward the New Mexico border of this plain the strata have stronger dip and erosion has exposed the edges of the strata along the Rocky mountain front. The Cretaceous terranes are covered with a mantle of Tertiary gravels derived from the mountain front.

Dr. Keyes says: "The Las Vegas plateau, Llano Estacada, the bolson plains of New Mexico, and some of the broken plains of eastern Arizona seem to belong genetically together;" and he further says: "When the general bowing up of the region took place in Tertiary times, the great plain formed was partly a pleneplain of destructional land origin and partly a constructional plain of marine origin." From this it would appear that the bolson plains of New Mexico, as he describes them, are remnants of this old peneplain, and that the mountain blocks of the plateau of New Mexico were formed subsequent to the peneplanation of the Cretaceous and lateral beds. It is not possible at the present writing to present the data to show that the structure of the mountains of New Mexico will not sustain this position. It is the writer's desire in this discussion, to confine attention wholly to the valley forms.

Dr. Keyes says: "That the old bolson plain in the Rio Grande valley is at present about 1,500 feet above the river" and he refers to the Colorado river as being "a mile deep in its canyon" below the surface of the great plain which he has constructed in his hypothesis.

During a residence of four years in the Rio Grande valley, accompanied with considerable field work, it has not been my pleasure to see a single remnant of the old plain to which reference is made. The valley of the Rio Grande through New Mexico has an extremely complex and varied form, and history. I desire at the present writing to call attention to only a few points in its history bearing upon the particular discussion in hand, and what is said with reference to the valley includes only that section which lies within the territory of New Mexico. The river is at several points, notably at White Rock canyon, at Elephant buttes,

and at El Paso, cutting through a rock gorge upon a rock floor, but throughout most of its course it is meandering over a broad flood plain in a still broader shallow trough, the latter cut some 200 or 300 feet below the surface of the broad sheet of plain deposits locally known as mesas. The larger structural valley which is followed by the Rio Grande is undoubtedly of very complex origin and no general description would be adequate for any particular section of the river. From the limited amount of data in hand it would appear that in some sections the river is following the line of a great fault zone and in other sections it is apparently following along the axis of an immense anticline, which has been very deeply and broadly eroded. The great structural valley presents an average width of fifteen to twenty miles, measured across the surface of the great mesa plain.

If we examine into the structure of the mesas bordering the river, as presented by well sections and deeply cut arroyos, we find that it is made up wholly of sands, gravels, and clays of fluviatile origin. The materials composing the mesas have been largely derived from the lateral mountains. The depth of this mesa deposit in the old structural valley is not definitely known. A well over seven hundred feet deep at Albuquerque did not reveal the rock and as the top of this well is about 250 feet below the surface of the mesa plain and near the central portion of the great valley, we can see that the great structural trough has been filled by the mesa deposits to the depth of probably much more than a thousand feet. It is evident from many topographic features that the river once meandered over the upper surface of this mesa plain at least 250 feet above its present level. At about that time in the history of New Mexico there occurred a more or less general extrusion of basaltic lavas over many areas. At least two of these lava overflows reached down into the valley of the Rio Grande and attained such magnitude as to produce profound changes in the course of the river. The first of these which I will mention is the great lava flow in northern New Mexico which dammed the course of the Rio Grande above the White Rock canyon, and the second, the great lava flow south of San

Marcial, which deflected the course of the Rio Grande far to the west of its old valley through the Elephant Butte canyon and west of the Sierra de los Caballos, reaching its old course again just a little north of Las Cruces. The Jornada del Muerto lying between the San Andreas and the Sierra de los Caballos is undoubtedly the old valley of the Rio Grande, from which the river was diverted at the time of maximum aggradation and at the time of the great San Marcial lava flow. There is every reason to believe, from a careful study of the history of the Rio Grande that a cross section at the Jornada del Muerto is comparable in its history to a cross section of the river at Albuquerque, where the mesa deposits are known to be at least a thousand feet in depth. It is therefore evident that the plain of Jornada is in no way genetically related to the Llano Estacado, except in so far as concerns the Tertiary deposits of the latter. That the great mesas bordering the Rio Grande are wholly of fluviatile origin is further shown from the topographic characteristics in the vicinity of El Paso where the river runs through a narrow rock channel between the Franklin mountains and the range to the southwest.

Some few miles above El Paso, and on the west of the Franklin mountains are preserved other extensive remnants of the old gravel and talus plains which extend out from the canyons of the Franklin mountains at a level of 300 or 400 feet above the Rio Grande. Several miles to the west across the immediate channel of the Rio Grande are seen the opposite exposures of the same beds. Whether it was by the blocking of the old channel with another lava flow farther to the west or by the normal process of excessive aggradation, that the Rio Grande was forced through the narrow mountain pass at El Paso is yet undetermined, but that it is superposed in its present position upon an ancient col at El Paso is certain.

The second instance to which attention is directed is the great basin in New Mexico lying between the San Andreas and the Sacramento mountains, known as the White sands plain or the Hueco bolson.* This certainly is a typical bolson as the writer understands the use of the term. These

* Hill, U. S. Folio, No. 3, p. 9.

great plains are some sixty or seventy miles long and twenty to thirty miles wide with the Sacramento mountains on the east rising to an average level of 6,000 or 7,000 feet above the plains and the San Andreas and Organs on the west and the Sierra Oscuras on the north rising to a somewhat less elevation. The plains are very level or slightly depressed through the central axis and show a decided grade toward the south. In the upper part of this great plains valley are the white sands and the salt marshes of the ancient lake Otero basin recently described by Prof. C. L. Herrick, late of Socorro, New Mexico, in the September number of the GEOLOGIST 1904. At the northern end of the plains lies one of the most extensive lava flows in New Mexico, surpassed only probably by the great northern lava flow in Ria Arriba and Taos counties, and in western Valencia county. That the deposits forming the floor of this great basin are very deep and composed almost entirely of fluviatile material has been demonstrated by numerous wells which have been sunk through various portions of the plain ranging in depth from a few feet to a well in the southern portion of the plain over 2,000 feet deep, which did not even at that extreme depth reveal the rock.

North of the great lava flow lies the Chapedero mesa and still farther north of that are the Estancia plains (Sandoval bolson of Hill). While it cannot be definitely asserted with the data in hand, there are many facts which would seem to indicate that the Estancia plains and the white sands plains represent a g reat north and south structural valley, more or less parallel to the Rio Grande valley, from which the ancient river which occupied it, was either diverted by the extensive lava flows or by the normal processes of aggradation, or, what also seems very probable, that the sediments of the great bolson plains in these great structural valley sections have reached such enormous thickness that the waters of the through flowing drainage are at present entirely subterranean. There are many facts in hand to prove that there is a subterranean drainage which passes out of the southern end of this great axial trough.

In referring to the region of the Rio Pecos, Dr. Keyes says: "Of these the last two streams mentioned" (Rio

Pecos and Rio Grande) "flow in the broad valleys between lines of block mountains." And in another place refers to the long basin plains of the Pecos and states that the Pecos has cut down to a depth of 2,500 feet below the level of the old plain. It would seem that Dr. Keyes has failed to recognize the fact that the Rio Pecos derives most of its water supply from the eastern side of the ranges of the Rocky mountains; that the drainage of the river corresponds very closely with the strike of the Cretaceous beds, the Pecos itself being a very asymmetric river, having all of its tributaries of any consequence on its western side. And when it is borne in mind that the river is flowing in its southern course through southeastern New Mexico along the outcrop of a great bed of gypsum and that the Cretaceous terranes of the Llano Estacado are dipping to the eastward it will be seen that in the development of the Pecos valley the axial stream has been migrating slowly eastward down the dip of the strata against the edge of a hard stratum. On the westetrn side of the Pecos the surface of the region conforms very closely with a very hard limestone element of the Cretaceous series which rises rapidly toward the west nearly to the crests of the bordering mountains, while on the eastern side of the river there is a sharp escarpment of a few hundred feet from the upper edge of which extends the great plain of the Llano Estacado, which slopes gradually to the southeast, the surface of which is strewn with the Tertiary gravels. The Rio Pecos, therefore has no mountains bordering the eastern side of its valley and there are no extensive detrital plains in any way comparable to those of the Rio Grande along the course of the Pecos outside of the mountain valleys at its head waters, except the great frontal apron of Tertiary mountain wash just referred to.

If we are to assume that two thousand feet of sediments have been removed from the Llano Estacado then it might be proper to say that the Pecos is flowing 2,500 feet below the aggradation surface of the Cretaceous terranes; otherwise we must consider that the major portion of the valley of the Pecos is scarcely more than a good sized drainage ditch along the line of strike of the hard beds of the Cretaceous formation which underlies the Staked Plains region.

Concerning the bolsons of the Rio Mimbres or Antelope plains I have little data at hand except that it is well known that underneath the Antelope plains there is a large supply of subterranean water contained in deeply buried river gravels. It has never been my pleasure to visit the San Augustine plains, therefore I cannot speak authoritatively concerning this extensive bolson.

With this brief statement concerning some of the physiographic and structural features of New Mexico it seems to the writer that Dr. Keyes is not justified in classifying as a common physiographic type the great plains of the Llano Estacado to the eastward of New Mexico and the typical bolsons which occur within its borders. In the judgment of the writer it would not even be possible to place the border plains of the Rio Grande and of the Rio Pecos in the class of bolsons, and certainly such plains as the Hueco, Mimbres, the Estancia and the Jornado can bear no relation whatever to the great plateau plain through which the Colorado river has cut its grand canyon.

From the data in hand it appears to the writer that in New Mexico and much of the great basins region where the bolson plains form an important physiographic type, there is a common history of origin. The whole region has been at some time at a very much higher level than at present and subjected to such erosion that the great structural valleys of the entire region were worn out several thousand feet in depth. Every feature of origin seems to point with unmistakable finger to a time of such erosion, under atmospheric conditions of heavy participation, with a much higher elevation of the plateau than at the present time. There certainly was a time when the carrying capacity of the axial streams of all the valleys was much in excess of the loads of material furnished to them by their lateral tributaries and by torrential action of the characteristic method of precipitation of the semi-arid region, resulting in the supply of enormous quantities of material from the steep mountain slopes into the valleys in such quantities that the larger streams were vastly overtaxed and the period of aggradation was inaugurated. This period continued until the deposit in these ancient valleys accumulated to thousands of feet

in thickness. In many cases the valleys were so completely filled that the detrital plains of the neighboring valleys were united, giving the appearance of extensive plains with isolated islands or bordering ridges.

Where the flow of water in the larger drainage axis like the Rio Grande was sufficient, the river contributed largely in the process of aggradation and plains building.

At or near the time of maximum aggradation, in the New Mexico region, at least, occurred the period of great basaltic lava flows. These were so distributed that in some cases, the lava flowed on to the bolson plains of the great isolated valleys or into the great plains bordering the Rio Grande and other streams diverting their courses. This great period of subsidence and aggradation is most strikingly shown in portions of southern Arizona, where Dr. W. T. Lee of the Geological Survey, has told me that the fluviatile deposits following the great eroded channelways of the Colorado and other streams extend to several hundred feet below sea level as is abundantly attested by well data.

While it does not seem at all necessary to postulate the great deformations of the land to account for transitions from conditions of degradation to those of aggradaation, as in many cases variations of climatic conditions including precipitation and so on, may be sufficient causes, yet where it is known that the plain of degradation extends below the plain of the present marine base level, a difference in altitude must be assumed. Dr. D. W. Johnson in an extensive article on the High Plains and Their Utilization, published in the 21st annual report of the United States Geological Survey, Hydrographic Division, has described with much detail the method of the formation of the frontal aprons bordering the mountain areas in the semi arid regions with special reference to the great sheet of Tertiary gravels which are spread out over the high plains region, including the Llano Estacado. He presents a diagramatic section on page 729 of that report showing the relation of Tertiary gravels to the underlying Cretaceous over the Stake Plains plateau, and he rightfully, I believe, attributes their origin to the frontal ranges of the Rockies. His description of the method of formation and structure of the great Tertiary

plains is in accordance with the writer's views upon the same subject, and present the conditions which prevail throughout the western plateau and great basins region during a portion of Tertiary time.

That there is certainly a great similarity in the method of formation of the Tertiary deposits over the Llano Estacado and great bolsons of New Mexico, and the basin region there is no question. The same attitude of the land under uniform climatic conditions produced throughout the entire southwestetrn country more or less uniform phenomena of erosion and aggradation on the pre-existing land forms, but that the term bolson is to be applied to any and all portions of these deposits wherever found is to be much questioned. The same conditions which spread out a great sheet of gravels over the surface of the Cretaceous on the Llano Estacado produced an extensive filling in all the great mountain-bordered basins and erosion valleys of the plateau region.

Nor can we class as bolsons such plains of recent origin as occur along the Rio Grande, which have been described by Dr. Herrick, in the GEOLOGIST, vol. 33, June 1904, as clino -plains.

If we are to consider the section of the Rio Grande between Bernalillo and Socorro, the Jornado del Muerto, and the Mesilla valley as typical bolsons as described by Mr. Hill, and are also to consider the Roswell basin of the Pecos as a typical bolson, it seems certain that the Roswell bolson, so classified, must be of a much more recent origin than those of the Rio Grande, for the Rio Grande deposits seem to be correlated in time with the great Tertiary deposits over the surface of the Llano Estacado, while the deposits occupying the Roswell basin have been made since the erosion of that basin out of the Tertiary and Cretaceous formations of the Llano Estacado. Again if we are to confine our definition of the term bolson to plains formed within the structural valleys (using this latter term in a very broad sense)then we must exclude the Roswell valley from the class of bolsons, for the writer is satisfied that the section of the Pecos included within the borders of New Mexico is wholly an erosion form.

In no sense then can the extensive bolsons of New Mexico be grouped into a common class and referred to as remnants of the early Cretaceous peneplain preserved "merely by lack of erosion agencies." We must then take sharp issue with Dr. Keyes, when he says of the bolsons of New Mexico: "Bolson plains may be considered as sections of an upraised peneplain surface in its earliest infancy, in the stage when they are as yet untouched by stream action."

As a bolson plain is a constructional form and is not confined necessarily to any period of time it must be recognized that the bolson plain passes through a history of construction and destruction similar to that of any other constructional topographic form, and the various stgaes of its formation and destruction should be carefully noted. After the formation of the bolson plain the region may become subjected to intense erosion, which would eventually leave but remnants of the old plain, while a neighboring plain not subjected to such treatment might persist or even continue to develop its characteristics as a distinct physiographic type.

It seems to the writer that the bolson plain will find its proper place and recognition in the literature of topographic forms.

GLACIAL LAKES AND MARINE SUBMERGENCE IN THE HUDSON-CHAMPLAIN VALLEY.

By WARREN UPHAM, St. Paul Minn

Very important studies of the Quaternary history of the Hudson-Champlain valley have been recently published by Charles E. Peet and J. B. Woodworth, who have worked mainly, both in the field and in the study, without collaboration together, yet reaching closely similar conclusions.*

The work of Mr. Peet is a continuation from his service since 1893 on the Geological Survey of New Jersey, for which he mapped the Pleistocene deposits of the Palisade Ridge, bordering the Hudson river. His plans for extending this investigation along all the valley north to lake Champlain and the St. Lawrence were made under the direction of Prof. R. D. Salisbury, and the field work and presentation of results have been directed by Prof. T. C. Chamberlin; but the author claims the full responsibility for the opinions expressed. He had reached the main results some four years ago, and later gave attention chiefly to the crustal movement and the origin of the water body in the Hudson valley, whether lacustrine or marine.

Professor Woodworth gives in his two very elaborate publications the results of his surveys for the New York State Museum during the years 1900 to 1903, with the aid of field notes and advice by G. K. Gilbert from several seasons of his work in the St. Lawrence valley, where he had examined the country from lake Ontario around the northern slopes of the Adirondacks and southward on the west side of lake Champlain to West Chazy. That exploration led to the selection of the Mooers quadrangle for detailed mapping of its glacial drift and lacustrine and marine formations.

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* Glacial and Postglacial History of the Hudson and Champlain Valleys, by CHARLES EMERSON PEET; reprinted (1904), with slight revision, from the Journal of Geology, vol. xii, pp. 415-469, 617-661, July-August and October-November, 1904; with 27 figures in the text (maps, sections, profiles, and views from photographs).

Pleistocene Geology of Mooers Quadrangle, being a portion of Clinton County, including parts of the towns of Mooers, Champlain, Altona, Chazy, Dannemora, and Beekmantown, N. Y., by JAY BACKUS WOODWORTH (Bulletin 83, New York State Museum), June, 1905; pages 60, with 25 plates (maps, and views from photographs), and a folded map of the Glacial geology of Mooers Quadrangle.

Ancient Water Levels of the Champlain and Hudson Valleys, by JAY BACKUS WOODWORTH (Bulletin 84, New York State Museum), July, 1905; pages 65-265, with 28 plates (maps, profiles, and views), 24 figures in the text, and the Glacial map of the Mooers Quadrangle (the same as in the preceding bulletin).

In deference to McGee, Salisbury, and others, who regard the Lafayette and Columbia formations of the Atlantic coastal plain in southern New Jersey, and thence south to the Gulf of Mexico, as of marine deposition, Peet states very fully the arguments that would refer the Late Glacial water body in the Hudson valley to incursion of the sea. This would seem indeed to be the first and most obvious presumption, in view of the fossiliferous marine beds in the Champlain and St. Lawrence valleys at altitudes ranging to a maximum of 560 feet on Mt. Royal, at Montreal, while the divide between lake Champlain and the Hudson river, near Fort Edward, is only 147 feet above the sea level.

But no marine fossils are found in the abundant stratified gravel, sand, and clay deposits of the Hudson valley, which indicates, with the evidences of Quaternary uplift of the southern part of this valley and of the Long Island region and the southern Atlantic coast, that a land barrier on the south held a glacial lake in the Hudson and Champlain valleys, outflowing along the now submarine continuation of the course of the Hudson outside the Narrows. This explanation of the submerged shallow valley and of the modified drift and later stratified beds along the Hudson river, belonging to the time of recession of the continental ice-sheet, I have presented in various publications during the past fourteen years, having in 1892 given the name Hudson-Champlain to this glacial lake.*

In other papers I have argued against the supposed marine origin of the Lafayette and Columbia series, attributing them instead to river deposition on land areas, from erosion of the Appalachian mountain belt at times when that region has undergone epeirogenic uplifts.*

Although a marine or estuarine origin of the Hudson valley deposits is argued by Peet as fully as seems possible, he also gives full consideration to the evidences for the freshwater deposition of these beds, evidently deeming this the more probable view, so that he leaves this question open and undecided.

* Geol. Soc. of America, Bulletin, vol. iii, pp. 484-487.

* Am. Jour. Sci., third series, vol. xli, pp. 33-52, Jan., 1891. Am. Naturalist, vol. xxviii, pp 979-988, Dec., 1894. Proc., A. A. A. S., vol. xliii, 1894. Compte Rendu du Congrès Géologique International, Zurich, 1894, pp 238-251. Am Geologist vol. xxv, pp. 313-314, May, 1900.

Woodworth takes more definite ground in support of the explanation of the Hudson beds as sediments of a glacial lake, to which he gives the name Lake Albany; and the glacial lake of the Champlain valley, which he thinks to have been later and distinct, he names Lake Vermont. To the present writer, however, it seems quite certain that the glacially dammed water bodies of these two parts of the Hudson-Champlain valley were continuous at the same levels, changed with the gradual northward uplift of the valley, forming deltas and shore lines which are interrupted by conditions of topography and sedimentation, but which by exact surveys with levelling will be traced continuously from the Hudson valley northward around the marine area of the Champlain,, St. Lawrence, and Ottawa basins, lying at higher altitudes than the marine shores and fossiliferous beds.

By my examination, in 1901, of the lowest part of the water divide between the Hudson and the Champlain, published in the AMERICAN GEOLOGIST for October, 1903, I could find no evidences of outflow there from the glacially ponded waters of the Champlain basin. That divide or lowest place of the watershed, near Fort Edward, seems to me to have been covered by the Hudson-Champlain glacial lake, and by the later glacial Lake St. Lawrence, until the continued departure of the ice-sheet far north allowed the sea to come into the St. Lawrence and Champlain valleys, then filling the southern part of the latter nearly to the hight of this col of its watershed.

The names Lake Albany and Lake Vermont, applied by Woodworth, seem to be synonyms of my previous nomenclature as lakes Hudson-Champlain and St. Lawrence, published in my U. S. Geological Survey monograph of Lake Agassiz and in other papers,* which, however, are not included in the extended bibliography given by Woodworth for this subject, although he cites a large number of my

* Geol. Soc. of America, vol. iii, pp. 484-7, 1892. Am. Jour. Sci., third series, vol. xlix, pp. 1-18, with map, Jan., 1895. Minnesota Geol. and Nat. Hist. Survey. Twenty-third Annual Report, for 1894 (pub. Feb., 1895), pp. 156-193, with map. U. S. Geol. Survey, Monograph xxv, The Glacial Lake Aggassoz, 1895, pp. 254, 262-264. AM. GEOLOGIST, vol. xxxii, pp. 223--230, Oct., 1903. International Quarterly, vol. xi, pp. 248-265, July, 1905.

earlier glacial papers. Several very noteworthy papers by others, also, as Elias Lewis, Jr.,† and Prof. J. S. Newberry,‡ relating to Long Island and the Hudson valley, are similarly overlooked in his bibliography.

From consideration of the amount and probable rate of the rise of the Champlain and St. Lawrence region from the Late Glacial and Postglacial marine submergence, Woodworth estimates the duration of the Postglacial epoch as somewhere between 20,000 and 100,000 years. The present writer has shown, however, that nearly all the uplifting of the Lake Agassiz area took place probably within so short a time as about one thousand years, during the existence of that lake, since which time the region has been affected only by very slight changes of level. Likewise probably the uprise of the St. Lawrence basin was at first relatively rapid, so that it might all take place within the period of about 7,000 or 6,000 years which is indicated for Postglacial time in that part of the northern United States and Canada by Prof. N. H. Winchell in his studies of the recession of the Falls of St. Anthony, with which my studies of the Niagara falls and gorge well coincide. The former estimate of the period since the Ice age as tens of thousands of years, still advocated by Gilbert and Woodworth, is opposed by a great range of well accordant evidences on the glaciated areas of both North America and Europe.

This Hudson-Champlain area, made classic in glacial geology by the work of C. H. Hitchcock, Baldwin, Baron de Geer, Gilbert, Merrill, Peet, Woodworth, and others, which through the writings of Hitchcock and Dana gave the name Champlain to the closing epoch of the Ice age, deserves yet further work of detailed surveys, with exact levelling for determination of the relations of all its lacustrine and marine shore lines. No other area of our continent promises more important information concerning the Glacial and Recent periods.

It should also be added that the deeply submerged outer fjord of the Hudson, made known with exact soundings and charting by Lindenkohl, is the key to the causes of the

† Pop. Sci. Monthly, vol. x, pp. 434-446, Feb., 1877.
‡ Pop. Sci. Monthly, vol. xiii, pp. 641-660, Oct., 1878.

Glacial period, by its testimony of very great preglacial land elevation, together with the similar evidence given by the submarine continuations of the Congo, the Adour, and other rivers, and by the profound depths of the Scandinavian and Arctic fjords.

THE JURASSIC HORIZON AROUND THE SOUTHERN END OF THE ROCKY MOUNTAINS.

By CHARLES R. KEYES, Socorro, New Mexico

Soon after passing the Colorado line the Rocky mountains rapidly lose their predominant characteristics and fade out completely into the Mexican tableland. The mountain ranges which succeed to the southward are short, isolated, tilted blocks, that are of a wholly different type from that of the mountainous structures to the northward, and to which they present marked topographic contrasts.

At this southern extremity of the Rockies in northern New Mexico, the general stratigraphy presents some unlooked for phases that are of exceptional interest. Moreover, it is here that the eastern Mississippi valley stratigraphy, with which American workers are most familiar, loses its identity and is replaced by a less known western stratigraphy. The rock-successions of these two provinces have never been satisfactorily or exactly paralleled. Of the many stratigraphic problems that have arisen recently for solution in this region none has possessed greater interest than the questions surrounding the horizon at which the Jurassic system should be represented.

Ever since the time of Jules Marcou's trip, sixty years ago, in connection with the Pacific railroad expedition along the thirty-fifth parallel, when he pronounced the now celebrated Tucumcari section in eastern New Mexico as of Triassic and Jurassic ages, there has been waged one of the bitterest and most useless controversies in the history of American geology. Marcou was well acquainted with Jurassic and Triassic sections of Europe and, as Louis Agassiz has well remarked,* he could hardly be blamed for seeing

* Am. Jour. Sci., (1), vol. xxvii, p. 134, 1859.

a close analogy in the New Mexican sequence. The full force of this position finds another instructive parallel in the so-called Permian question of central Kansas.†

Both of these controversies doubtlessly would have been avoided had all participants relied less on analogy and more upon the actual critical criteria which the formations themselves supply.

Singularly enough, after all these years in which Marcou has stoutly maintained the correctness of his original position, the "Triassic" part of the Tucumcari section appears finally to be determined without much doubt as Triassic in age. It now becomes a question of more than passing interest to inquire anew regarding Marcou's Jurassic beds of the same locality.

According to Marcou's Pyramid mountain section, which is near the Cerro Tucumcari, and which is essentially the same, there were included in his so-called Jurassic sequence (a) about 225 feet of soft, shaly, light-colored sandstones, which Hill has since correlated with the Trinity sands of central Texas, (b) 50 feet of bluish fossiliferous shales, which Hill considers as forming the uppermost poriton of the Washita division of the Comanche series, and from which Marcou collected his few fossils, and (c) 50 feet of massive yellow calcareous sandstone, which has since been found to be the attenuated extension of the Dakota sandstone. Even within the last decade Cummins has gathered all of these beds into a single unit and proposed for them the title of the Tucumcari formation.* All of these formations at Tucumcari appear to form a perfectly conformable succession.

More extended observations have lately shown quite conclusively that marked unconformities actually exist between everyone of the formations mentioned. Regarding them many questions now arise concerning their real significance in the geological history of the region.

The remnant of the Dakota sandstone (c) which is found in the Tucumcari section is now known to form the base of the Mid-Cretaceous (Upper Cretaceous of Meek

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† Journal of Geology, vol. vii, pp. 221-241, 1899.
* Texas Geol. Sur., Third Ann. Rept., p. 201, 1892.

and Hayden). It rests unconformably on all older formations, from the Mid-Carboniferous limestones to the Comanche series.

The shale (b) beneath the massive sandstone at the top of the Tucumcari section, has been correlated with the topmost portion of the Washita division of the early Cretaceous as represented farther to the eastward in Texas. The lower members of the early Cretaceous successively thin out to the north and west from the central part of that state and each overlaps the next below.

The next formation below (a), which rests unconformably upon the Triassic Red Beds and which has been paralleled with the Trinity sands of central Texas appears to be a formation with as yet no tangibly determinable relationships. It may be the basal member of the early Cretaceous section which is so well developed farther to the eastward, and this has been the view advanced by Hill and other workers in the Texas field. Or, it may be a littoral deposit that followed up an advancing shore; and thus it may have an age in its different parts extending throughout the Comanche period. However, this phase of the subject receives full discussion elsewhere.

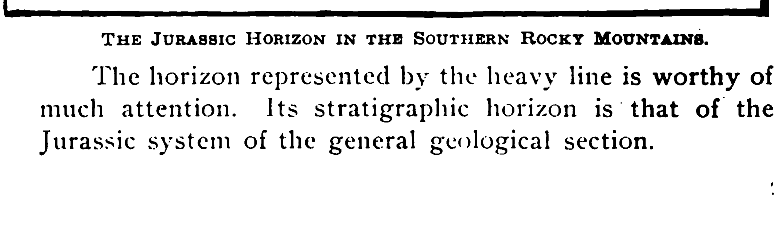
This so-called Trinity sandstone stands apart from all else. It has no direct genetic relationships with the formations either above or below. The unconformable relations that it bears both to the superior strata and to the inferior rocks clearly indicates the lapse of a considerable time interval at least at the base. There is then in this sandstone an important geological formation about which little is yet definitely known regarding its geological relationships; and to the westward at the same horizon an important erosion interval is represented. The equivalents of these in the sediments of other localities, as well as the space they represent in the general geological column have become topics of some speculation.

White, who was long the best American authority on the Cretaceous rocks, considered the Trinity sands, or Dinosaur beds, as reaching down into the Jurassic period. Marcou regarded the Jurassic as partially represented by this formation. Most writers have disputed the existence

of any Jurassic beds in this part of the continent. Their evidence has been even less conclusive than that presented by the pioneer geologist just mentioned. It is now known that Marcou and his critics were not discussing exactly the same thing.

Independent of whatever may have been concluded in the past regarding the presence or absence of Jurassic deposits in the Tucumcari section it is certain that there exists at the horizon where the Jurassic system is naturally located in the general geological column, a stratigraphic gap and a formation about which there is much to learn before their real significance is understood. It may be that after all Marcou's surmise was right and that the Jurassic system finds representation in the Cerro Tucumcari, just as it now appears that his shrewd guess regarding the Triassic eventually proved to be correct.

In this connection it is of interest to note that in western New Mexico, in the Zuni region, Dutton has regarded the great sequence of sandstones which he called the Zuni series, and which is upwards of 1,200 feet thick, as very likely of Jurassic age. He correlated this series with the extensixe deposits of so-called Jurassic age in Arizona, Utah and southwestern Colorado. The Zuni series for the present is here still associated with the Triassic system. Its stratigraphic relationships, especially with the Dakota sandstones, and the position in the Tucumcari region are indicated in the section subjoined (Fig. ..).



THE JURASSIC HORIZON IN THE SOUTHERN ROCKY MOUNTAINS.

The horizon represented by the heavy line is worthy of much attention. Its stratigraphic horizon is that of the Jurassic system of the general geological section.

EL INSTITUTO GEOLOGICA DE MEXICO.

By F. N. GUILD, TUSCON, ARIZ.

PLATE XV.

Since the International Congress of Geologists is to convene in the city of Mexico during the coming summer of 1906, it may be interesting to the readers of the AMERICAN GEOLOGIST and especially to those who expect to attend the congress, to learn something of the work of the Institute in Mexico which corresponds to our national geological survey. Such a description seems especially opportune at the present time when the Institute has taken up its quarters in an excellent new building expressly designed for its purposes, and is now busily engaged in sending invitations to all parts of the world and making other preparations for the congress which is to be held within its walls.

The first step which led to definite results in the formation of a geological survey in Mexico was made in 1886 and through the efforts of Antonio del Castillo, then professor of mineralogy and geology in the School of Mines, an authorization was obtained two years later for the formation of a Comision Geologica de México. The first publication issued in 1895 appeared under the title of Boletin de la Comision Geologica de México. Later, however, the name was changed to Instituto Geologico National de México and the publications appeared under that name. Castillo, who may be considered as the founder of the Institute, was chosen director which position he held until his death in 1895. One of the first objects of the Institute seems to have been the preparation of sketches (bosquejos) on the general geology of the country. These appear in bulletins No. 4, 5, and 6. They are accounts of scientific expeditions by various members of the staff into different parts of the republic.

The Institute was first housed in the School of Mines building, later however, removed to temporary quarters in the Calle de Paseo Nuevó Num. 2, and finally into its present building on 5a Calle del Ciprés. It is equipped with excellent chemical laboratories for the analysis of rocks and minerals, museums for geological and mineralogical collections, drafting rooms, libraries, laboratories for microscopic

investigation, and all necessary appliances for geologic research. The museum is especially well equipped with a large collection of nicely trimmed rocks and thin sections corresponding. Possibly there is no better place than Mexico for the study of variations in rhyolitic and andesitic outflows, and the Instituto Geologico keeps its doors open to scientists who desire to study there. The staff of the Institute at present consists of José G. Aguilera, appointed director on the death of Castillo, Ezequiel Ordonez, subdirector and petrographer, Emilio Böse, Carlos Burckhardt, Juan D. Villarello, E. Angermann, T. Flores, R. Robles, S. Truax, and A. Villafana, geologists, R. Santillan, secretary, F. Roel, and V. de Vigier, chemists.

The Institute has an interesting and in some respects unique field for investigation. The larger portion of the sedimentaries and older crystalline rocks in Mexico are covered by great masses of recent products of volcanic activity such as ashes, andesitic and basaltic outflows. The Institute has a very complete collection of these rocks which have quite thoroughly been worked out from a petrographical standpoint and presented to the public through its excellent bulletins. Its investigators plan in the near future to discuss more completely the chemical relations of the outflows and doubtless valuable additions will be made to our knowledge of the differentiation of volcanic magmas. Volcanic craters are found everywhere, some in the state of activity (Colima) others possessing but faint traces of their former power (Popocatepetl). Even within less than two hours ride from the city of Mexico groups of volcanoes may be studied where crater cones rise but a few hundred feet above the level valley of Mexico (Sierra de Catarina.) These present variations from pure cinder cones (Las Calderas) to cones from the crater of which more liquid material has escaped (Cerro de Ixtapalapa). Thus a more ideal spot for the investigation of at least one phase of geology could hardly be imagined.

Following is a list of the publications of the Institute:

Num. 1.—Fauna Fósil de la Sierra de Catorce, por A. del Castillo y J. G. Aguilera.—1895.—56 pp., 21 lám.

Num. 2.—Las Rocas Eruptivas del S. O. de la Cuenca de México, por E. Ordónez.—1895.—46 pp., 1 lám.

Num. 3.—La Geografia Fisica y la Geologia de la Peninsula de Yucatán, por C. Sapper.—1896.—58 pp., 6 lám.

Nums. 4, 5 y 6.—Bosquejo Geológico de México.—1897.—272 pp., 5 lám.

Nums. 7, 8 y 9.—El Mineral de Pachuca.—1897.—184 pp., 14 lám.

Num. 10.—Bibliografia Geológica y Minera de la República Mexicana por R. Aguilar y Santillán.—1898.—158 pp.

Num. 11.—Catálogos sistemático y geográfico de las especies mineralógicas de la Republica Mexicana, por José G. Aguilera.—1898.—158 pp.

Num. 12.—El Real del Monte, por E. Ordónez y M. Rangel.—1899.—108 pp., 26 lám.

Num. 13.—Geologia de los alrededores de Orizaba, con un perfil de la vertiente oriental de la Mesa Central de México, por Emilio Böse.—1899.—78 pp., 3 lám.

Num. 14.—Las Rhyolitas de México (Primera parte), por E. Ordónez.—1900.—78 pp., 6 lám.

Num. 15.—Las Rhyolitas de México (Segunda parte), por E. Ordónez.—1901.—78 pp., 6 lám.

Numero 16.—Los Criaderos de fierro del Cerro del Mercado en Durango, por M. Rangel, y de la Hacienda de Vaquerias, Estado de Hidalgo, por J. D. Villarello y E. Böse.—1902.—144 pp., 5 lám.

Numero 17.—Bibliografia Geológica y Minera de la Republica Mexicana por R. Aguilar y Santillán.—1904. [*En prensa.*]

PARERGONES.

Tomo I. No. 1.—Los temblores de Zanatepec, Oaxaca.—Estado actual del Volcán de Tacaná, Chiapas, por Emilio Böse.—1903. 25 pp., 4 lám.

No. 2.—Fisiografia, Geologia é Hidrologia de los alrededores de la Paz, Baja California, por E. Angermann.—El área cubierta por la ceniza del Volcán de Santa Maria, Octubre de 1902, por Emilio Böse.—1904. 26 pp., 3 lám.

No. 3.—El Mineral de Angangueo, Michoacán, por E. Ordónez.—Análisis de una muestra de granate del Mineral de Pihuamo, Jalisco, por J. D. Villarello.—Apuntes sobre el Paleozoico en Sonora, por E. Angermann.—1904. 34 pp., 2 lám.

No. 4.—Estudio de la teoria quimica propuesta por el Sr. Andrés Almaraz para explicar la formación del petróleo de Aragón, México, D. F., por J. D. Villarello.—El fierro meteórico de Bacubirito, Sinaloa, por E. Angermann.—Las aguas subterráneas de Amozoc, Puebla, por E. Ordónez.—1904.—24 pp., 1 lámina.

No. 5.—Informe sobre el temblor del 16 de Enero de 1902 en el Estado de Guerrero, por los Dres. E. Böse y E. Angermann.—Estudio de una muestra de mineral asbestiforme procedente del Rancho del Ahuacatillo, Distrito de Zinapécuaro, E. de Michoacán, por el Ing. J. D. Villarello.—1904.—26 pp.

No. 6.—Estudio de la hidrologia subterránea de la región de Cadereyta Méndez, E. de Querétaro; por el Ing. J. D. Villarello.—1904. —58 pp., 2 lám.

No. 7.—Estudio de una muestra de grafita de Ejutla, Estado de Oaxaca, por el Ing. J. D. Villarello.—Análisis de las cenizas del volcán de Santa Maria, Guatemala, yor el Ing. E. Ordóñez.—1904.—26 pp.

No. 8.—Hidrologia subterránea de los alrededores de Querétaro, por el Ing. J. D. Villarello.—1905.—56 pp., 3 láminas y 2 figuras.

City of Mexico, Aug. 25, 1905.

SERPENTINES IN THE NEIGHBORHOOD OF PHILADELPHIA.

ANNA I. JONAS, Bryn Mawr, Pa.

The object of this paper is to give a brief review of the occurrence and origin of the known serpentines, and to describe in particular, the serpentine dykes in the neighborhood of Philadelphia, Penna.

It is generally conceded that serpentine, wherever occurring as a mineral or a rock, is a secondary product formed in the zone of katamorphism and that it is developed by the alteration of non-aluminous, ferro-magnesian silicates; olivine, the pyroxenes, anthophyllite, tremolite and actinolite. In a less number of cases serpentine has been derived from a limestone.

An entire rock mass may be composed exclusively of serpentine, or the rock may contain remains of the original minerals from which the serpentine was derived. The physical characters of the rock serpentine are therefore somewhat modified by the presence of associated minerals. In color serpentine has a wide range through all shades of green, brown and reddish brown. Its texture depends largely on the mineral from which it was derived; serpentine formed by the hydration of olivine is massive; that variety formed by the alteration of an amphibole is usually fibrous. That variety which results from the alteration of pryoxene may be described as massive.

Since serpentine, a katamorphic product, is not easily weathered, it usually forms a ridge scantily covered with a sterile soil composed of silica, magnesia and stained with iron oxide.

Distribution.—Serpentine has a wide distribution through the British Isles and Europe, and has been described from several localities in Asia and Africa. The serpentines of England, Wales and Scotland have been traced to olivine rocks and are usually associated with masses of gabbro or dioryte. The serpentines of Europe, for the most part, occur in belts of igneous rocks and crystalline schists and gneisses, and are largely derived from peridotytes, pyroxenytes or gabbros. Serpentinised marble is re-reported from the Passauer gneiss district of central Europe, from the upper Reno valley of Italy and from the Knopia district of Finland, and serpentine is associated with calcareous schists on Corsica and at Antioch, Asia.

In America serpentine is found throughout the belt of crystalline formations which extends from Maine to Alabama and forms the floor of the Piedmont plateau.

Maine.—*In Maine, serpentine has been reported by Mr. George P. Merrill at the northern end of Deer Isle in Penobscot bay. He describes it as a very dark green variety mottled by diallage crystals.

Vermont.—There are many localities of serpentine in the state of Vermont† on the boundary between Dover and Newfane counties, at Windham; in the hills of the northwestern part of Chester extending to Ludlow and Cavendish; at Plymouth, Roxbury, Westfield and Troy. The serpentine is associated with steatite and occurs both in mica schists and gneisses. It is placed among the stratified rocks because it occurs as thick beds in foliated rocks and does not cut them. This could be accounted for on the supposition that the serpentine was an intrusive which had been folded along with the rock into which it was intruded. The steep slopes of Belvidere‡ mountain are composed of amphibolyte. In it the hornblende has been largely altered to fibrous serpentine.

Massachusetts.—In the Holyoke folio Emerson discusses the serpentine which extends from Holyoke, Massachusetts, south into Connecticut. The Chester amphibolyte

*G. P. Merrill, "Stones for Building and Decoration," p. 60.
† Geology of Vermon 1861, vol. i, p. 544.
‡ Science, vol. xxi, No. 533, Mar. 17, 1905 (review). "The Serpentine and Associated Minerals of Belvidere mountain, Vermont," by V. F. Marsters.

is described as a "dark, flaggy hornblende schist," in part replaced by serpentine and emery. In an earlier publication it was described as an altered eruptive, but in this folio Emerson calls it an altered sediment, probably a dolomyte and of Lower Silurian age, lying between the Rowe and Savoy schists, both of which are sericite schists. Emerson decided that the Chester amphibolyte is a sediment because in the sedimentary series of Connecticut, Massachusetts and Vermont there are beds of dolomyte which pass into enstatite limestones and amphibolytes. Not only is emery found in limestones but the amphibolytes of the above mentioned series are derived from limestones. The Pelham gneiss* is exposed in long, narrow strips, extending north and south and lying to the east of the Connecticut river in Pelham and Shuttesbury. In this gneiss are dykes of a bronzite-olivine rock partially altered to serpentine.

In this monograph Emerson mentions the occurrence of serpentine in the Chester amphibolyte. It enters Massachusetts from Vermont and extends southwest through Rowe, Hampshire, Hampden, Blauford, Granville and Russel counties and dips below the sands of the Westfield plain and does not reappear.

New York.—In 1887 Dr. Williams published a paper on the serpentine† in the Onondaga salt group at Syracuse. The exposure was situated on James street but for many years has been inaccessible. It was noted in 1837 and reported to Vaunuxem, the state geologist, who regarded it as an aqueous deposit. Dr. Williams claims for it an igneous origin;‡ in 1890 he published some additional proof for his view.

§ In Essex county at Port Henry and Moriah, there is serpentine derived from an altered dolomyte and pyroxene limestone. A similar rock is found in Warren county. Serpentine is associated with limestone in St. Lawrence county, New York.

* Serpentine from the vicinity of New York City is found at Rye and New Rochelle in West Chester county,

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* Monograph xxix of U. S. G. S. by B. K. EMERSON.
† Am. Jour. Sci., 3rd Ser., vol. 34, p. 137, "The Serpentine of Syracuse, New York," by G. H. WILLIAMS.
‡ Bull. Geol. Soc. Am., vol. 1, pp 595-606.
§ G. P. MERRILL, "Stones for Building and Decoration."

INSTITUTO GEOLOGICA DE MEXICO.

at Staten Island in New York City and at Castle Point, Hoboken, N. J.

† Mr. Newland has described all these serpentines and believes that they are derived from pyroxenytes and peridotytes. He objects to J. D. Dana's view that the New Rochelle serpentine is derived from a limestone containing intruded silicates. ‡ Mr. F. J. H. Merrill says that the serpentine of New Rochelle, is derived chiefly from amphibole and bronzite which are almost completely serpentinised. The rocks from which serpentine was derived were amphibolytes and other magnesian silicate rocks intruded into Ordovician schists.* Julien describes in detail, amphibole schists, (pyroxene schists), diorytc schists and gneisses throughout Manhattan island. The one area of serpentine that is of importance occupies a long belt between West Fifty-fourth and Sixty-third streets from Tenth avenue to the Hudson river. It represents a further alteration product of the hornblende schists; both are alterations of basic igneous intrusions.

New Jersey.—A different origin has been proposed for the deposits at Montville, N. J.† Mr. G. P. Merrill considers the serpentine to be the result of the alteration of a non-aluminous pyroxene enclosed in a magnesian limestone. At Mendham in the same belt of limestone there is found serpentine with a similar origin.

Pennsylvania.—In Pennsylvania serpentine is found in Northampton, Bucks, Montgomery, Delaware, Chester and Lancaster counties, forming in general, lenticular areas with a strike southwest and northeast. *There is an area north of Easton in Northampton county and small areas along the Lehigh river. The Easton area occurs on the southeastern slope of Chestnut hill. The hill is composed of pre-Cambrian gneisses interstratified with beds of cal-

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* New York Acad. Trans., vol. i, p. 58.

† School of Mines Quarterly, Apr. 1901, p. 307, July 1901, p. 399, article by D. H NEWLAND.

‡ Appendix A. The Geology of the Crystalline Rocks of Southeastern New York, by F J. MERRILL, Reprinted rfom the New York State Museum Report, 1896.

* Bull. of Geo. Soc. Am., vol. 12, pp. 421-494. Genesis of the Amphibole Schists and Serpentines of Manhattan Island, N. Y., by ALEXIS A. JULIEN.

† Proceed. U. S. Nat. Mus., vol. xii.

* Reprint from Annals N. Y. Acad. Sci., vol. xiii., No. 6 .pp. 419-430. Jan. 14, 1901, by F. B PECK.

cite and dolomite which furnish the main source of the serpentine. In Bucks county there are two small serpentine areas on the west bank of Neshaminy creek, which are products of the alteration of basic intrusives. The northern is associated with gabbro and the southern area is intrusive in the Wissahickon mica-gneiss.

*The serpentines of the Philadelphia belt of crystalline rocks occur in a series of dykes which extend through Montgomery county into Delaware and Chester counties; they will be described in detail later.

The so-called state line serpentines are a continuation of one of these dykes. They extend for sixteen miles along the boundary between Pennsylvania and Maryland, beginning in Chester county, at Little Elk creek, and extending into Lancaster county and southwest into Cecil county, Maryland.† These like the other serpentines are altered eruptives.‡ They are associated with pyroxenytes and peridotytes and they represent the alteration product of these rocks. From Cecil county westward through Harford* † and Baltimore counties, southwest along the base of Parrs ridge, across Howard and Montgomery counties to the Potomac. They are secondary products of both pyroxenytes and peridotytes.

Delaware.—From the northeast corner of Delaware, extending southwest into Maryland is a belt of gabbro and associated rock types.‡ At Chestnut Hill and Iron Hill the peridotyte is serpentinised. In Delaware there is one other serpentine area. It lies in northern New Castle county east of Red Clay creek. It is intrusive in the mica-gneiss and with it as is frequently the case, are associated pegmatytes which may represent the most acid phase of the magma of which the mother rock of serpentine is the most basic.

Virginia.—In Virginia W. B. Rogers has described serpentine from the soapstone rocks of Nelson* and Amherst counties.

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* Bull. 13, Geo. Soc. Amer.
† F. D. CHESTER, Penna. Geol. Surv., Ann. Rept., 1887, pp. 93-105.
‡ Maryland Geol. Surv., Rept. of Cecil Co., F. BASCOM.
* Am. Geol., July, 1890. The Non-Feldspathic Intrusive rocks of Maryland, by G. H. WILLIAMS
† These serpentines have been described by DR. A. JOHANNSEN in an elaborate paper which has not yet been published.
‡ Bull. 59, U. S. G. S., 1896, by FREDERICK D. CHESTER

North Carolina.—† The peridotyte serpentine belt of North Carolina is scattered over an area forty miles wide. For the most part the peridotyte is fresh and its olivine shows but slight alteration to serpentine. South of Waynesville there is only one small area of massive serpentine but to the north in Buncombe, Madison and Yancey counties there is much typical massive serpentine.

‡ *Georgia*—In Harris county, western Georgia, Clements reports serpentine. It is derived from the peridotyte of the belt which extends into Georgia from Carolina and bears corundum.§ This belt extends westward into ‖ eastern Alabama and there contains serpentine associated with steatite. This is the most southerly extension of the belt of crystallines with which serpentine is associated and which extends throughout the Atlantic states.

There are scattered areas of serpentine in Texas, Minnesota and Colorado. In the Cascade and Sierra Nevada mountains of Washington and Oregon and in the coast range of California, in the Sacramento valley and on the San Franciscan peninsula, serpentine has been described and its origin traced to pyroxenytes and peridotytes.

The Serpentines of the Philadelphia Belt.—The Piedmont belt of the eastern United States lies between the Appalachian province to the west and the coastal plain region to the east. It extends from Maine southwest to middle Alabama. Its surface is rolling with flat topped hills separated by deep cut valleys. On these hills is seen the remnant of the Jurassic peneplain; after this peneplain had received its load of Cretaceous sediments and had been raised above sea level, streams began to cut into the Cretaceous sediments. They wore through them and cut gorges into the crystalline rocks of the Piedmont.

The rocks across which the streams flow are gneisses, quartzyte, marble and schists, closely folded and faulted. They are cut by eruptives which range widely in composition. There are two belts of crystallines separated by a cover of Triassic sandstone.

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* Geology of the Virginias, 1884, W B. ROGERS, p. 296-297.
† Geol. Surv. of N. Car., 1896, Bull. 11, by LEWIS.
‡ Bull. 5, Alabama Surv.
§ Bull. 2, Geol. Surv. Georgia, on Corundum Deposits.
‖ Bull. 5, Alabama Surv., by ALFRED BROOKS.

In the southeastern belt, the oldest rock is the Baltimore gneiss of pre-Cambrian age. It is composed of light bands of quartz and feldspar alternating with dark hornblendic layers, closely folded and contorted. This rock together with gabbro forms Buckridge and strikes northeast and southwest, separating the Cambro-Silurian series of quartzyte, limestone and mica-schist from the Wissahickon mica-gneiss to the southeast. Unconformably overlying the Baltimore gneiss is the Chickies quartzyte, a thinly bedded crystalline rock full of sericite, which gives it a buff to green color and a schistose character. This resistant rock forms the ridge of the north Chester valley hills. To the south of these hills is the limestone of the Chester valley. It is a magnesian limestone of Cambro-Silurian age and it grades upward into the Hudson River mica-schist, which caps the south Chester valley hills. The mica-schist is a schistose rock composed of mica and quartz; the quartz is present in lenses about which the mica is bent.

The age of the Wissahickon mica-gneiss has not yet been fully worked out. The rock is silvery gray in color, with alternating schistose and gneissic bands. Abundant mica shows on the cleavage planes and quartz and feldspar on planes at right angles to the cleavage.

The Triassic cover of red sandstone and shale still remains over a portion of the Piedmont plateau. Contemporaneous with the deposition of the Triassic beds was a flow of basalt and an intrusion of diabase extending from Connecticut to Virginia. In Pennsylvania this resulted in a series of diabase dykes which extend southwest through the plateau.

The older igneous rocks are more abundant in the region. There was a period of post-Ordovician and pre-Triassic activity which assisted the forces of regional metamorphism in altering the sedimentary Palæozoic and pre-Palæozoic rocks. The igneous material is granite and gabbroitic, the main mass is gabbro which, in the vicinity of Philadelphia is intruded into the Baltimore gneiss and mica-gneiss. The rock is either an augite, or hypersthene-gabbro penetrated by dykes of peridotytes or pyroxenytes.—It is

these ultra basic rocks which furnish the original material from which the serpentine is derived.

* The serpentines of the Philadelphia belt occur as dykes, intrusive in the mica-gneiss and Baltimore gneiss and strike southwest and northeast.

They may be grouped into four dykes, each composed of a series of non-continuous outcrops extending southwest from near the Schuylkill. They form prominent ridges which are covered but scantily with soil and which are characterised often by a growth of cedar trees.

The southeast dyke is intrusive in the Wissahickon mica-gneiss and extends from Chestnut Hill southwest to one mile east of Bryn Mawr station. The dyke as exposed at Lafayette is typically a grayish green soapstone. At Black Rock quarry the serpentine is a grayish green rock mottled with large dark green olivine crystals; specimens have been found in which are large cross twins of serpentinised olivine. Under the microscope the mass of the rock is steatite, appearing with crossed nicols as brilliantly polarising scales. The steatite is considered to be an alteration product both of an original pryoxene and of the serpentine which it penetrates. The olivine present is altered only along the periphery and cracks and cores of it still remain. In addition the rock contains very abundant calcite and magnetite.

The rock is an altered peridotyte whose original constituents are olivine and pyroxene which have altered to serpentinised talc and the by-products which accompany serpentinisation. Along the contact of the dyke with the mica-gneiss there has been formed chlorite-schist, a green schistose rock composed of chlorite with needles of hornblende.

The second dyke lies to the northwest of the first and is intrusive in the Wissahickon mica-gneiss close to the boundary between it and the Baltimore gneiss. The dyke shows an exposure east of the Schuylkill. From Lafayette on the west side of the river it extends southwest with almost continuous outcrops to Delaware county where it widens out considerably. The rock is very similar to that

of the dyke just described. In microscopic section it shows serpentine altered from olivine and secondary tremolite and anthophyllite partially altered to serpentine. Enstatite may be present fresh or unaltered. Talc, calcite and magnetite occur in abundance. From the fresh structure seen under the microscope and the presence of olivine in various stages of alteration to serpentine the original rock is decided to be a peridotyte.

The third dyke shows one exposure in Montgomery county. On the edge of the gabbro area, along Arrowmink creek. A second exposure known as Castle Rock, is situated in Delaware county near Edgemont. It is an example of serpentine resulting from the alteration of a pyroxenyte. The rock is medium grained and dark green, composed of fibrous tremolite, augite, enstatite and talc. The original pyroxenes are augite and enstatite while tremolite is a necessary product. All three minerals show alteration to talc which pierces them in all directions. This description applies to a specimen obtained from the center of the mass; in an outlying portion the rock is almost completely serpentinised and is a dense, massive, green serpentine of uniform character. The rectangular cleavage of augite outlined by iron oxide can be seen in the serpentine.

The outcrop of the fourth dyke extends sporadically from Guelph Mills, in Montgomery county southwest into Chester county. Three-fourths of a mile south of Paoli the dyke gives rise to a barren ridge which is a distinct topographic feature for ten miles to the southeast. The rock south of Paoli is a light yellowish green serpentine very massive in character and yet under the microscope showing evidence of alteration from olivine and in a small part from a pyroxene.

A study of the field relations and microscopic sections of the serpentines of the Philadelphia belt shows that they are secondary to pyroxenytes and peridotytes which they have in a large measure replaced. Such an origin has been ascribed to the greater part of the serpentines of the world and it is only in a few cases that they have been regarded as secondary products of sedimentary rocks.

AN EXPLANATION OF THE PHENOMENA SEEN IN THE BECKE METHOD OF DETERMINING INDEX OF REFRACTION.*

By W. O. Hotchkiss, Madison, Wis.

In the identification of minerals in rock sections the method of procedure is always the determination of the fixed physical properties. Among these constants, the ones which are ordinarily employed on account of their easy determination are the index of refraction, birefringence, positive or negative character, orientation of the plane of the optic axes, and angle of the optic axes. Cleavage and extinction angles are also useful when the orientation of the section can be ascertained with any degree of certainty. Among these properties the refractive index and the birefringence are probably known for the widest range of minerals and are therefore most useful. The latter is readily determined by the method described by L. V. Pirsson and H. H. Robinson.† The former is measured by the method of Count von Chaulnes (see Rosenbusch-Iddings for description of method) and by the Becke method. The first method gives the numerical index but is clumsy and inaccurate; the latter merely indicates whether the index is higher or lower than that of the contiguous medium, but it is easily applied and is so delicate that differences in refractive index of .001 have been observed by the originator of the method. The extreme usefulness of the Becke method led the writer to endeavor to find a more detailed explanation of the phenomena observed. The construction, given below, it is believed, will satisfactorily explain all the phenomena.

Let us assume A B, in fig. 1, to be a cross-section of two minerals with indices of 1.50 and 1.70 respectively, whose plane of contact is represented by the line C-D and is perpendicular to the page. Then if the section be in a microscope arranged to give convergent polarized light the convergent rays will come from below and the objective lie above the cross-section as shown. Ray 1 is refracted so as

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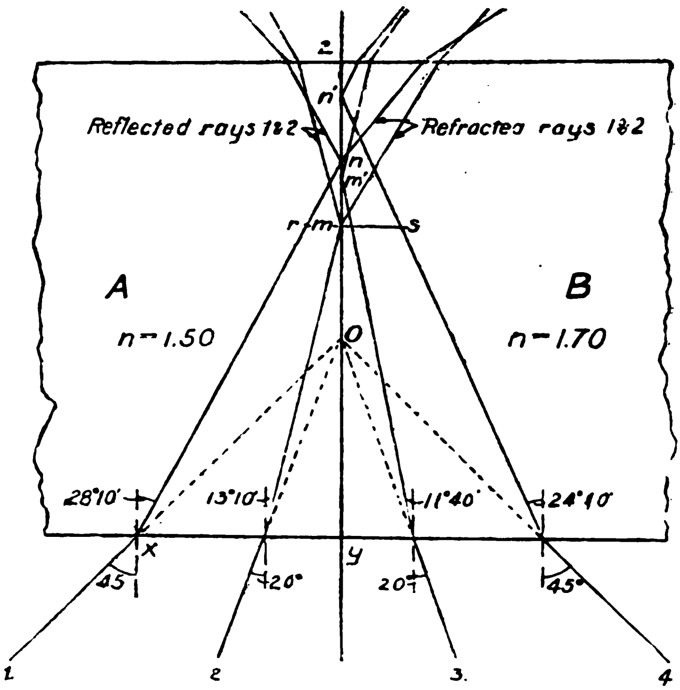
*Ueber die Bestimmbarkeit der Gesteinsgemengtheile, besonders der plagioklase auf Grund ihres Lichtbrechungsvermögens. Sitzungsb. k. Akad. Wiss. Wien, Mathem—naturw. Classe. Bd. CII. Abth. I. Juli, 1893, pp. 358-376. See also Rosenbusch-Iddings, appendix.

† A. J. S., 4th Ser., vol. x, pp. 260-265, 1900.

to meet the plane between the two media at the point n, at a distance above the point x of 1.87 times the length x-y. Ray 2 meets it at m, a distance equal to 1.56 times x-y. Rays 3 and 4, since B has higher index, are refracted to meet the plane at points m′ and n′, higher than the similar rays in A, or at distances above y of 1.76 and 2.18 times x-y, respectively.

At the surface of contact between A and B the critical angle is 62° 10′ and so all rays incident on y-z from B at an angle greater than 62° 10′ are totally reflected back into B.



On the other hand, a portion of the light from A incident upon y-z is refracted into B. The ratio between the amount reflected and the amount refracted depends upon several factors. In proportion as the contact surfaces of A and B are highly polished, more light is reflected and less refracted; as the angle of incidence increases more light is reflected and less refracted; and as the difference in the in-

dices increases the amount of light reflected becomes greater. Since the contact surface of minerals in rocks is seldom smooth the tendency is for a large part of the light from A to be refracted into B, and the condition obtains as shown in the figure,—that for a certain vertical distance along the contact, approximately equal to mn′, nearly all the light will be on side of the mineral having the higher index. If the objective of our microscope is focused within this vertical distance a band of light will be seen, if it is raised the band will be seen to broaden, as is evident from the directions of the refracted and totally reflected rays. If, on the other hand, the objective is lowered, the band becomes narrower and finally is brighter on the side of the mineral of lower index. This is explained by the fact that the light in A, which is approximately the same in amount as that in B at this distance above the base of the section, is concentrated in a band of width mr which is shorter than ms and will therefore show greater intensity. As the objective is lowered, the bright band in A and the less bright one in B broaden out.

If rays from B are incident upon y-z at an angle less than the critical angle (62° 10′ in the case illustrated), they will not be totally reflected but will partly pass through into A. If there is sufficient light thus refracted a bright band will be seen in A as well as in B when the objective is raised. It is important therefore to diaphragm the light entering the condensing system to such an extent that all the light from B is totally reflected at the contact surface. This increases the relative brightness of the band seen in B.

Computations of the different values of the distances from y to m and n were made for other indices besides the two figured. The angles of incidence of the four converging rays were taken as 45° and 20° as in the figure and the distance from x to y was taken as unity.

It is evident from this table that the distance from n to n′ (see fig. 1) is quite within the range of observable quantities even for slight differences in index of refraction. The lengths of yn and ym for indices of 1.54 and 1.56 were com-

Index	Angles of refraction for Incidence of 45°	20°	y n	y m	Diff. (n-m)
1.50	28° 10′	13° 10′	1.87	1.56	.31
1.54	27° 20′	12° 50′	1.93	1.60	.33
1.56	27° 0′	12° 40′	1.96	1.62	.34
1.60	26° 10′	12° 20′	2.04	1.66	.38
1.70	24° 40′	11° 40′	2.18	1.76	.42
2.00	20° 40′	9° 50′	2.65	2.10	.55

puted with this in mind. In these yn for 1.54 is .03 less than for 1.56. If these figures are reduced so as to be comparable with the thickness of microscope sections, the difference in a section of .030 mm. thick would be about .0005 mm.—a magnitude which, though hard to measure accurately, is easily observed.

The difference between ym and yn bears a fairly constant ratio to yn for the common range of indices—being about one-sixth. This in a slide .030 mm. thick would be .005 if yn be taken as the thickness of the plate. This magnitude (.005) is about the average change in focus necessary to cause the bright band to shift from one side of the contact to the other. Within this distance the light coming from the side having the greater index is totally reflected, while from the other side the larger part is refracted at the contact. Therefore the focus must be changed through a distance of this order of magnitude in order to show the band on opposite sides.

The application of this method of determining relative index of refraction is very simple. If the instrument used is not provided with a diaphragm below the condensing lense, the hand may be used to shade the mirror, thus cutting off part of the light. As a matter of experience it is found that the hand is used quite as frequently as the diaphragm by one accustomed to the method. The fact that as the objective is raised the light band goes to the side of the higher index and vice versa provides a simple memory rule—focus high, band on side of higher index; focus low, band on side of lower index.

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EDITORIAL COMMENT.

CONSOLIDATION OF THE GEOLOGIST WITH ECONOMIC GEOLOGY.

It is announced among the advertisements of this issue of the AMERICAN GEOLOGIST that the GEOLOGIST will be consolidated, after January 1, 1906, with the new journal, ECONOMIC GEOLOGY and the facts of interest to subscribers are there treated. It remains to make further comment from the editor's standpoint.

When the AMERICAN GEOLOGIST was started(1888) there was no distinctively geological journal in America, and the Geological Society of America had not yet been organized. The United States Geological Survey was in a transitional stage. Geology in America was represented in the International Congress of Geologists by a number of delegates from the American Association for the Advancement of Science. If American geology found any means of expressing itself its voice was likely to be muffled by passing through non-sympathetic agencies.

These things have changed. The science is not only more independent and urgent in the presentation of its interests, but has come into recognition more and more as an element in modern civilization which needs to be cared for, as well as a producer and safe-guard of a large share of the wealth and comfort of the nation.

The aspect of American geology, as expressed in the purposes and publications of the various geological surveys, has changed within the past 18 years. Time was when the director of the United States Geological Survey, in its extension over the older states of the Union, defined the sphere of that survey to be the study and publication of paleontological and structural problems, united with the mapping of the nation's domain, leaving for the various state surveys the investigation of economic subjects. Within a few years, however, the economic features of the United States Survey have expanded enormously. The efficiency of the survey and the judiciousness of its expenditures have won from Congress larger and larger sums of money, and have led to the extension of its activities over wider and wider fields of

research. The various state surveys have also devoted their energies more fully to the question—how to make the survey immediately useful. Pure science, excepting so far as it is prompted and promoted by the search for the useful, has been less in evidence in the state reports.

In volume 14 of the GEOLOGIST (p. 186) in an editorial are the following words:

"It is not too much to say that to the miner, and hence to the mining industry, geology must look for most of its future progress, at least in the United States. In Canada the economic side of geology has always been put to the front, and systematic geology has been comparatively neglected. The reverse has been the case in the United States. The example of New York State, which has entirely neglected, officially, its economic resources, and has spent much upon the technical and paleontologic aspects of geological science,* has been followed by too many of the state surveys, and too closely by the United States Survey. Economic geology has made headway in spite of this indifference. Speculative and technical geology has had the field for many years, but it becomes more and more apparent that room must be made for an extension of that phase of the science which directly concerns the greatest number of people."

The present witnesses the greatest expansion of the mining industry known to our history. It is in the flood of this movement that the AMERICAN GEOLOGIST is consolidated with the new journal which is to be more closely linked with economic geology.

In looking over the published plans and purposes of the editors of the GEOLOGIST, the editors are constrained to admit that not all of their plans and promises have been accomplished; but it is with no feeling of regret or apology that they see some of their announced plans and hopes still unrealized. Some of the editors who evolved those plans have died, and new editors have substituted other contributions, which were probably equally within the scope of the journal.

We had aimed to issue short biographical sketches of all deceased American geologists, but in some notable instances our efforts have failed. Seventy such sketches have been published in the GEOLOGIST. We have had correspondence to this end concerning Lieber, Little, Rogers,

* In the reorganization of the New York Geological Survey, in 1903, there has been made provisions for the investigation and report on the economic geology of the state.

Marcou, Gesner, King, Vanuxem, Alexander, Percival, Brooks, Eames, and others, and have gathered some unarranged data. It is to be hoped that these efforts may be pushed by some one to future fruition. There is no better place to preserve the personality and the record of the scientific labors of geologists than in a sympathetic geological journal. This has been (or had been) neglected in the United States.

In laying down the active and responsible management of the journal the editors revert to the record of the past 18 years with satisfaction. They are sure that on the whole the influence of the published volumes has been wholesome. They fill a niche in the passing history of geology in America which, they trust, will be consulted with profit by the future student. The years 1888 to 1906 have been crowded with important geological research and with improvements in the methods of geological work, and the AMERICAN GEOLOGIST has contributed its quota to the progress that is so apparent. The editors wish to express their warmest thanks to the contributors who have co-operated with them, and to bespeak for the new editors the same cordial cooperation.

N. H. W.

The first few years the GEOLOGIST was maintained with financial loss to the editors. Not counting anything for expense of editorial management, the GEOLOGIST has been self-sustaining for about ten years, and for the last five or six years there has been a surplus of a few hundred dollars annually above actual expenses, the largest annual surplus having been $542. The sole reason for surrendering this charge is the desire on the part of the managing editor, with advancing years, to find time for some other contemplated work. The GEOLOGIST, as a journal was never in as good condition as at the present time.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The secondary origin of certain granites, R A. DALY. (Am. Jour. Sci., vol. 20, Sept. 1905.)

This paper throws much light on the manner of origin of certain acid igneous rocks. In the prosecution of the survey of the international boundary between Canada and the United States, in the region between Port Hill, Idaho and Gateway, Montana, are found enormous thicknesses of quartzytes associated with argillytes. Dr. Daly here found numerous sills of gabbro lying parallel in the strata, some of the sills having a thickness of 2,500 feet, while the sedimentary rocks afford a total of about 20,000 feet of bedding exposed to geological study. The sedimentary rocks are divided into Creston quartzyte (at the bottom), the Kitchener quartzyte and the Moyie argillyte.

The sills, where in their present normal condition, were found to consist of hornblende gabbro, with some accessory quartz, titanite, biotite, and a little orthoclase. While this is not a gabbro it is assumed by the author to be the primary intrusive magma that entered the sedimentaries. These accessories increase as the rock varies from its original composition in the vicinity of the planes of contact with the sedimentary rocks, especially the orthoclase, quartz and biotite, accompanied, also, by microperthite. There is, further, a variation in the structural relations. The quartz becomes poikilitic to all the other constituents except the orthoclase and the microperthite, and with these it forms a micrographic intergrowth.

These phenomena are most marked in the greatest sills, the largest being denominated the Moyie sill, rather more than 2500 feet in thickness. While the quartzytes have been thoroughly metamorphosed, and especially feldspathized, near the sill, the gabbroid rock has been more profoundly altered. This alteration is most extensive along the upper contact of the sill, where the hornblendes are obliterated and in the place of labradorite is the feldspar andesine. Biotite is much increased in amount and soda-orthoclase also occurs, along with much quartz; microperthite, micropegmatyte, calcite, muscovite and epidote are also found along the contact. At fifteen feet from the upper contact hornblende is still wanting. The same is true of labradorite: oligoclase is 1.0 per cent, soda-bearing orthoclase is 32.5 per cent and quartz 41 per cent. There is also muscovite and titaniferous magnetite. At 50 feet from the upper contact, while hornblende and labradorite are still wanting, oligoclase constitutes 1.5 per cent and orthoclase 24.9 per cent. Quartz is here 57. per cent, and calcite 2.5 per cent. At 200 feet from the same contact hornblende is 19.4 per cent, biotite is

22. per cent, andesine is 16.5 per cent, oligoclase and soda-bearing orthoclase are wanting and quartz is 11.7 per cent. This variation continues to diminish toward the body of the sill until the endomorphic alteration fades out into the normal sill rock.

The rock at 15 feet from the upper contact belongs to the granite family. Toward the sill the rock varies more and more toward the gabbro type and toward the contact the variation is more and more toward granophyre granite. Xenoliths from the quartzyte present the same zones of metamorphism.

The author calls attention to similar cases of profound alteration at contacts of basic intrusives on siliceous clastic rocks in Minnesota and in Ontario, viz: at Pigeon point and at Sudbury, where have been described granitic and intermediate rocks resulting from such contact, acting themselves as igneous rocks and forming characteristic intrusions in the manner of dikes.

These phenomena are regarded by the author as demonstrating the assimilation theory at the points discussed. In his synthetic discussion he makes the following remarks:

"The secondary origin of granite has long been maintained by N. H. Winchell who has referred to the Pigeon Point case as among others, demonstrating the fact.* Bayley came to the same belief for the granite and granophyre of the point but he did not extend his argument in detail to cover other occurrences among the Minnesota intrusives. On the other hand the principle has not been accepted as applying to these localities even by Van Hise whose rare knowledge of Lake Superior geology must give his opinion exceptional weight.† Even the latest text books of geology give most inadequate treatment of the doctrine though it refers to one of the most important problems in the whole field of geology. Doubtless the majority of petrologists are to-day unfavorable to the assimilation theory of granite and its relatives except as it applies to a very limited, in point of volume insignificant, modification of certain magmas at their contacts.

"Van Hise's chief argument against the contact origin of the Pigeon Point granite emphasizes the fact that that rock has not the chemical composition either of the sedimentary formation or (as especially shown in the surplus of alkalies and the deficiency of iron in the granophyre granite) of a direct mixture of gabbro and sediments.‡ The much quoted argument of Brögger with reference to the Norwegian granites is based on a similar fact.§ Many other writers have, on a similar ground, excluded contact assimilation as playing any considerable part in the formation of abyssal or hypabyssal magmas.

"In practically every case the opponents of the assimilation theory have treated of the assimilation as essentially a static phe-

* Final Report, Minnesota Geological Survey, vol. 5, p. 62, etc., 1900.
† Monograph 47, U. S. Geol. Sur., 1904, pp. 730-733.
‡ Op. cit., p. 733.
§ Die Eruptivgesteine des Christianiagebietes. Pt. 2, 1895, p. 130.

nomenon. Each interpretation of field facts has been phrased in terms of magmatic differentiation versus magmatic assimilation as explaining the eruptive rocks actually seen on the contacts discussed. Nothing seems more probable, however, than that such rocks are often to be referred to the compound process of assimilation accompanied and followed by magmatic differentiation. The chemical composition of an intrusive rock at a contact of magmatic assimilation is thus not simply the direct product of digestion. It is the net result of re-arrangements brought about in the compound magma of assimilation. In the magma, intrusion currents, convection currents and the currents set up by the sinking or rising of xenoliths must take a part in destroying any simple relation between the chemical constituents of the intrusive and the invaded formations. Still more effective may be the laws of differention in a magma made heterogeneous by the absorption of foreign material which is itself generally heterogeneous. The formation of eutectic compounds or mixtures, the development of density stratification, and other causes for the chemical and physical resorting of materials in the new magma, ought certainly to be regarded as of powerful effect in the same sense."

The author mentions other defects in the arguments usually launched against assimilation, and concludes as follows:

"In the foregoing discussion the secondary origin of some granites has been deduced from the study of intrusive sills or sheets; but it is evidently by no means necessary that the igneous rock body should have the sill form. The wider and more important question is immediately at hand—does the assimilation-differentiation theory apply to truly abyssal contacts? Do the granites of stocks and batholiths sometimes originate in a manner similar or analogous to that just outlined for the sills?

"The writer has briefly noted general reasons affording affirmative answers to these questions.*

"Gabbro and granophyre are often characteristically associated at various localities in the British islands as in other parts of the world.† The field relations are not there so simple as in the case of the Moyie sill, for example, but otherwise the occurrence of many common features among all these rock associations suggests the possibility of extending the assimilation-differentiation theory to all the granophyres. Harker's excellent memoir on the gabbro and granophyre of the Carrock Fell district, England, shows remarkable parallels between 'laccolite rocks' and those of Minnesota and Ontario.‡

"At Carrock Fell there is again a commonly recurring transition from the granophyre to true granite, and again the granophyre is a peripheral phase. Still larger bodies of gabbro, digesting acid

* Am. Jour. Sci., vol. 15, 1903, p. 269; vol. 16, 1903, p. 107.
† See A. GEIKIE. Ancient volcanoes of Great Britain, 1897.
‡ Quart. Jour. Geol. Soc., vol. 50, 1894, p. 311, and vol. 51, 1895, p. 125.

sediments yet more energetically than in the intrusive sheets, and at still greater depth, would yield a thoroughly granular acid rock as the product of that absorption with the consequent differentiation. This does not imply, of course, that all granites are of this origin, but it is quite possible that most intrusive granites are either of this origin or have been more or less modified through assimilation.

"The difficulty of discussing those questions is largely owing to the absence of accessible lower contacts in the average granite body. All the more valuable must be the information derived from intrusive sills. The comparative variety of such rock relations as are described in this paper does not at all indicate the exceptional nature of the petrogenic events signalized in the Moyie, Pigeon Point or Sudbury intrusives. It is manifest that extensive assimilation and differentiation can only take place in sills when the sills are thick, well buried, and originally of high temperature. All these conditions apply to each case cited in the present paper. The phenomena described are relatively rare largely because *thick* basic sills cutting acid sediments are comparatively rare.

"On the other hand, there are good reasons for believing that a sub-crustal gabbroid magma, actually or potentially fluid, is general all round the earth; and secondly, that the overlying solid rocks are, on the average, crystalline schists and sediments more acid than gabbro. Through local, though widespread and profound, assimilation of those acid terranes by the gabbro, accompanied and followed by differentiation, the batholitic granites may in large part have been derived.* True batholiths of gabbro are rare, perhaps because batholitic intrusion is always dependent on assimilation.

"The argument necessarily extends still farther. It is not logical to restrict the assimilation-differentiation theory to the granites. The preparation of the magmas from which syenites and diorites, for example, have crystallized, may have been similarly affected by the local assimilation of special rock formations. The development of some of the anorthosites of the Canadian and Adirondack Archean was possibly conditioned on the digestion of part of the associated crystalline limestones by plutonic magma.

"The officers of the Minnesota Geological survey have shown that the same magma represented in the soda-granite and granophyre of Pigeon Point forms both dikes and amygdaloidal surface flows.† The assimilation-differentiation theory is evidently as applicable to lavas as to intrusive bodies. But demonstration of the truth or error of the theory will doubtless be found in the study of intrusive igneous bodies rather than in the study of volcanoes either ancient or modern.

* Cf. R. A. Daly, op. cit.

† N. H. Winchell. Final report, Minn. Geol. Sur., vol. 4, 1899, pp. 519-22.

"Finally the fact of 'consanguinity' among the igneous rocks of a petrographical province may be due as much to assimilation as to differentiation."

Mr. Daly has certainly added an important chapter to the literature of the igneous rocks. The reviewer would suggest that probably the hornblende gabbro of the Moyie sill is itself a secondary rock, differing from true gabbro in the same direction as its contact phases differ from the body of the sill. The true gabbro of Minnesota was found to acquire hornblende and quartz, and often orthoclase, when it came into contact or contiguity with the acid sediments of the Animikie. It is quite possible and logical to suppose that a mass of true gabbro magma, in the lapse of time, lying beneath the earth's crust, or perhaps in contact with the lower part of the quartzytes discussed by Dr. Daly, would suffer such endomorphic changes on a grand scale as to afford large quantities of hornblende-gabbro, and nothing else, in case of later intrusion into the overlying sediments. N H. W

La Montagne Pelèe et ses èruptions, par A Lacroix. Quarto, 650 pages, 30 plates. Paris, 1904, 238 figures.

This work is published by the Academy of Sciences, under the auspices of the ministers of public instruction and of the colonies. On opening the volume the reader is presented, in the frontispiece, with a heliograph of perhaps the most wonderful natural scene ever photographed—the "burning cloud" of the 16th of December, 1902, at the point of its arrival at the sea. Its hight, as it fades away and breaks into the air above was 4000 meters, or somewhat more than 13,000 feet. Its wedge-shaped, boiling front seems to roll along on the earth, occupying the valley of the stream. At the sea-level its foot spurts out upon the water somewhat like the advance of the water of a tremendous comber after it has broken upon the beach. Its higher portions are more advanced than its foot, but throughout its front its convoluted shape is marked and preserved, rendering it apparent that the great mass is as distinct from the atmospheric air as the dark thunder clouds of mid summer. It is only in the rear of the cloud that its outlines are confused and lost. Certainly no similar volcanic phenomenon was ever before so truthfully and so vividly reproduced. Hovey and Heilprin have published numerous excellent views of these steam-ash clouds taken usually from near the crater and showing partially the wonderful convolutions they undergo. Lacroix's photo was taken from across the sea level, and includes the entire cloud from bottom to top. To the observer it must have presented a sublime and portentous aspect. Of the results of the devastation of such a death-dealing cloud, the destruction of St. Pierre, the author says:

"J' ai rapporté une impression inoubliable, non seulement des phénomènes grandioses et passionnants auxquels j' ai assisté, mais encore des infortunes dont j' ai été le temoin, des spectacles tragi-

ques de cette campagne de six mois, de ces longues chevauchées dans la ville détruite et sur cette Montagne Pelée, naguere veritable Eden, aujourd' hui terre ravagée, couverte d' un gris linceul de cendres, qui n' évoque plus que des souvenirs de désolation et de mort!"

The *burning clouds*, and the *dome* and spine formed at the crater are, according to Lacroix, the two capital new facts of the great eruption. The book contains a great many new things of minor importance, and new discussions, presented in the inimitable and clear style of Lacroix, but the treatment of those dominating scientific facts in vulcanism gives to the volume a unique value. The work is divided into three parts, not including a bibliography of the geology and geography of the volcanic islands of the West Indies, beginning in 1640 and concluding with late publications consulted even during the process of printing of the volume. The first part treats not only of the physics of volcanic activity but presents in detail the facts of the late eruptions. The second part is taken up with petrographic discussion of the ashes, bombes, lavas and all ejecta of the present and of past eruptions of Martinique, and by a comparison of these with similar rocks from others of the volcanic islands of the East Indies. Part three is devoted to certain minerals and rocks produced from the building stones and some artificial substances by the burning of St. Pierre.

Part 1 contains a mass of descriptive details, with numerous photographic illustrations. At the present we can refer specifically only to the dome and the burning clouds. As to the former the author says: "The present eruption has been characterized particularly by this fact, that the gaseous emanations and the ejection of solid matter have been through a single opening, above which was built up rapidly a dome of andesyte whence thereafter all the explosive phenomena arose. It will be seen later that this dome did not present a permanent yawning, crater-like opening during all the time that I studied it. If it had one, or several, during the paroxysms, which is quite likely, they were of very short duration. There is then, properly speaking, no crater of the present eruption, in the sense that one generally gives to the word crater. But this dome, in place of being raised from any point of the volcanic ground of Mont Pelée, has ascended from the depths of an old caldera, from an old explosive crater which, in the first weeks of the eruption, before the appearance of the dome, consequently played the role of a veritable crater. In fact there is an incasement of two successive volcanic formations, the products of different mechanism." The author, however, applies the term crater, in his descriptions, to that part of the old caldera which has not yet been filled by the solid mass of the dome, nor by the pieces that become detached from it. This view is quite different from that entertained by *Heil-

* The tower of Pelée; new studies of the great volcano of Martinique. ANGELO HEILPRIN, 1904, p. 34.

prin, who believes that the spine, or tower, consists of an ancient core or plug remaining since the last eruption, now dislodged and thrust upward by renewal of volcanic activity. Lacroix, however, in his *resume et conclusions*, (p. 643) details more specifically his theory of the origination of the celebrated spine. Thus:

"The mechanism of the production of *domes*, which are composed principally of rocks but little fusible (rhyolytes, trachytes, andesytes, phonolytes) in so many regions, remained to the present very obscure, no direct observation having as yet permitted the following of the steps of growth of this kind of volcanic mountain. We know now, by a concrete example, how such a dome is produced. The molten magma, reaching the surface, by means of some fissure, forms there a mass which is quickly surrounded by a solid shell. This carapace not only protects the interior against too rapid congelation but through the fissures formed in its surface by contraction exudes a frothy lava which adds, according to the internal pressure, intermittently new quantities of molten matter to the exterior. Thus it increases in hight and in size, a constant rocky mass bristling with asperitics, bounded by abrupt walls which rise in the midst of the talus of fallen pieces which are constantly increased by superficial crumbling. Materials ejected by the paroxysms of activity play a very insignificant role and often take no part in the constitution of such a dome.

"The dome thus constructed is not pierced by any yawning opening, permanent as a crater, but the paroxysmal explosions produce in it temporary openings which are again rapidly sealed. When the external shell becomes so firm that it cannot longer yield to expansion in all directions the internal pressure is locally effective at a limited number of points, producing then the extrusion of solid rocky masses which may rise as if drawn through framed orifices, forming needles which may reach the hight of several hundred feet, in the manner of that whose birth and growth I witnessed and examined day by day during several months. In the course of a single eruption the point of concentration of effective pressure can be displaced, forming thus successive spines, varying in form, dimensions and position."

The destructive agent of the eruption, the *nuèes ardentes*, are regarded as the result of explosion issuing from the flanks of the dome, at Mont Pelée, but from the depth of the open crater at Saint Vincent. The explosion furnished an enormous mass of gas and water vapor, released rapidly on reaching the atmosphere, carrying along a considerable quantity of solid matter of all forms. Instead of being always projected vertically these clouds roll with great swiftness down the slopes of the mountain. In the case of feeble eruptions gravity has a determining influence upon their course, but in great paroxysms they are moved more rapidly, due to the accumulated action of the initial projection and of gravity acting

in the same direction. At Mont Pelée the position of the orifice of escape of these gases had a preponderating influence on their direction.

"These clouds, possessing at their starting a high temperature which becomes slowly lessened, have a considerable mechanical and calorific force, which explains the complete annihilation of a large city and its inhabitants, as well as the extension of the destructive effects to the distance of ten kilometers from their point of origin."

The scientific world is under obligation no more to the French republic than to the French savant for this grand and most satisfcatory treatise. N. H. W.

Minerals in rock sections; the practical methods of determining minerals in rock sections with the microscope, especially arranged for students in technical and scientific schools. LEA McILVAINE LUQUER, Adjunct professor of mineralogy, Columbia University, New York City, Revised edition. New York, D. Van Nostrand Company, 1905. 147 pages, $1.50 net.

This revision of a useful and well-known text book has been improved by an enlargement of that part relating to the determination of the plagioclases, by the explanation and illustration of the Becke method of relative refraction in contiguous minerals, and by many additicns in chapters I, III and IV; also by tables of refractive indices, of double refraction, and a diagram showing the relation between strength of double refraction, interference colors and thickness of section, the last being an adaptation from Michel Lévy's color scheme of double refraction accompanying *Minéraux des Roches* by Lévy and Lacroix. N. H. W.

Geology of Western Ore Deposits. ARTHUR LAKES, late professor of geology at the Colorado School of Mines; New Edition, entirely rewritten and enlarged, with 300 illustrations, 438 pages. Kendrick Book and Stationery Company, Denver, Colo., $2.50, postpaid.

Colorado has the chief share in this work, although its descriptions range from Alaska southward. It is well illustrated, frequently by sketches by the author, and its statements are correct and clear. The extended acquaintance of the author with the mining and methods of the Rocky mountain region has contributed a large share to the contents of this book though it is still largely, and necessarily, a compilation from other authorities—Emmons, Spurr, Weed, Van Hise, Kemp and others. The book cannot fail to be of great usefulness to the mining industry of the west. N. H. W.

Grundzüge der Gesteinskunde; 1 Teil, Allgemeine Gesteinskunde als Grundslage de Geologie. ERNST WEINSCHENK, mit 47 Textfiguren und 3 Tafln. Seiten 163, 1902, 4 marks. Freiburg, Wein, Strass-

burg, München, St. Louis, Mo., B. Herder: *II Teil, Spezielle. Gesteinskunde mit besonderer Berüsichtigung der geologischen Verhältnisse,* mit 133 Textfiguren und 8 Tafeln. Seiten 331, 1905, 9 marks, Freiburg, Wien, Strassburg, München und St. Louis, Mo., B. Herder.

These volumes are comparisons of the same author's *Gesteinsbildenen Mineralien* and *Anleitung zum Gebrauch des Polarisationsmikroskops* which are well known petrographical text books. Together they constitute a series by a single author covering the whole field of lithology. It is sometimes an advantage to a student after he has become familiar with the terms and usages of an author to be able to transfer his attention to another branch of the science without the necessity of acquiring the ready use of a lot of new terms.

Part I. contains a resumé of the known distribution and *mise en place* of the different kinds of rock masses. It has little to do with the composition of rocks, but describes vulcanism and the forms of rock masses it produces, the first crust of the earth and the crystalline schists, magmatic differences, rock-weathering, denudation, nature and distribution of sediments, eolian and alluvial deposits, marine sediments, glacial deposits, metamorphism, its agents, and its products, both contact and regional, and all forms of rock structures. It has a full and useful index.

Part II. treats of rock species, going through the whole gamut from granite and gabbro to the sedimentary rocks whether mechanical, chemical or organic, with a good index. A special chapter is devoted to the crystalline schists.

Both these parts are well illustrated with half-tones from photographs. The German is simple and easily read by a novice in that language. The work is distinctively a German production, with little reference to English and French literature.

N. H. W.

Structural and Field Geology. JAMES GEIKIE Murchison, professor of Geology and Mineralogy in the University of Edinburg, for students of pure and applied science. New York. D. Van Nostrand Company, 1905, pp. 435, 56 plates and 142 illustrations in the text. $4.00, net.

This book is remarkable for two things—It has no references to authorities, and it does not touch on paleontology. It is what its title implies—structural and field geology—yet some might query whether it would have been, under that title, as reasonable to omit all reference to the mineral composition of rocks as all reference to their organic contents. Still, it is plain that the author had an idea, which he has tried to exemplify in his work. It is, further, very reasonable that a Scotch text-book on geology should reflect the dominant geological features of Scotland, and these certainly are not paleontologic. The illustrations are also taken from Scotch geology.

There are two other features which this book possesses which give it a unique character. These consist of detailed directions for geological surveying, i. e., the *how* and *what* to observe, and the methods of making maps and sections. These are essential to the equipment of a field geologist. It is necessary that the field geologist be expert in interpreting and expressing the significance of the topographic features. In the chapter on the "Economic aspects of Geological Structure" is a thorough discussion of underground water.

"This handbook addresses itself," as the author states in the preface, "in the first place to beginners in field geology, but I hope it may be found useful also to students who are preparing for professions in which some knowledge of Structural Geology is of practical importance." It is not therefore a handbook for the experienced geologist, dealing with geological problems, and investigations up to date. It only summarises the recognized fundamentals of geology. N. H. W.

Economic Geology of the United States, HEINRICH RIES, Asst. Professor of Economic Geology at Cornell University, pp. xxi, 435; plates 26; fig. 97. The Macmillan Company, New York, 1905. Price $2.60, net.

This work, which is intended to serve as an elementary textbook for students of economic geology, treats of the mode of occurrence, distribution and uses of both the non-metallic and the metallic minerals and rocks in the United States which are of economic value.

The book is divided into two parts: Part I. treating the nonmetallic minerals, and Part II. the metallic minerals. This arrangement, which is perhaps different from that usually followed, has been adopted, because the non-metallic minerals produced annually have a greater aggregate value, and also for the reason that this line of discussion leads from the simpler to the more difficult part of the subject.

Although an elementary work, the book contains also extensive lists of reference so that those desiring to pursue the subject further can do so. These references are grouped at the end of each chapter where they can be easily referred to by those needing them, but at the same time, by this arrangement they take up but little space in the book.

In treating each mineral the aim has been to discuss its general characters and economic value, followed by a description of a few localities which are of importance or may serve as types, rather than to give a mass of detailed descriptions, which often tend simply to confuse the student.

The difficult task of presenting in one volume of moderate size a description of the mineral resources of the United States, and of allotting to each subject the proper amount of attention, has been unusually well performed. The space given to non-metallic minerals covers 215 pages, while 194 pages are devoted to metallic ores

and minerals. The value of the book for reference is greatly enhanced by a good index. The authorities quoted are up to date, and chosen with discrimination.

A work of this nature will probably never be entirely free from inaccuracies. As an indication of conscientious work on the part of the reviewer and for the correction of future editions it may be well to call attention to a few slips: Thus, corundum is not really, next to diamond, "the hardest abrasive known" (p. 163). An important use for sulphur not mentioned (p. 198) is in the manufacture of paper; and zinc is largely used in the cyanide process of gold extraction (p. 320). Fault planes and sheer zones can hardly be called "cavities" (p. 231), although they may permit the circulation of waters underground. This idea resembles the old notion that "fissure veins" were once open, empty cracks of indefinite vertical and horizontal extent. It is also true that "crustification" is often observed in veins which are *not* "formed by the simple filling of a fissure" (p. 236).

Tellurides are not "unknown," but are often found at the contact of granitic intrusions and calcareous rocks (p. 235).

The "apex" of a vein may not "outcrop" at all (p. 238). "Ore bodies lacking in iron pyrites," but composed of chalcopyrite do sometimes show secondary enrichment (p. 245). Some blast furnaces now use more than 75% of Mesabi ores in their charge (p. 265); and the greater value of hematite ore is not due so much to its proximity to theoretical purity as to the readiness with which it is reduced by carbonaceous fuel as compared with magnetite (p. 252).

Altered copper ores are *not* usually more cheaply treated than sulphide ores, and chalcopyrite is not commonly considered a secondary ore (p. 281).

The large copper mines at Butte are from 2000 to 2500 feet deep instead of 1000 to 1500 and the vertical limit of the silver ore was determined long before the silver mines reached the depth of 1400 feet (p. 286). Douglass Houghton was an "A. B." and "M. D." and a geologist, but it is novel to hear him called "a mining engineer" (p. 287). Copper in the Lake Superior region is seldom if ever "refined electrolytically" (p. 290).

Sulphide of gold is certainly a rarity (p. 329); but so are really well-balanced works on economic geology in general. And the conclusion should not be drawn from the above series of minor corrections and suggestions that this is not a very valuable and useful addition to our literature on the subject which it treats. Necessarily condensed, it yet covers the ground in a thorough and authoritative manner and will be used by many as the most satisfactory text book available.

H. V. W.

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The Grande Soufrière of Guadeloupe. (Bull. Am. Geog. Soc., Sept., 1904.)

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The western Sierra Madre of the state of Chihuahua, Mexico. (Bull. Am. Geog. Soc., Sept., 1905.)

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Fossil horses of the Oligocene of the Cypress Hills, Assiniboia. (Trans. Roy. Soc. Can., 2nd series, vol. 11, Sec. 4, pp. 37-52, August, 1905.)

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Comment on the Report of the Special Committee on the Lake Superior Region. (Jour. Geol., vol. 13, pp. 457-462, July-Aug., 1905.)

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Genesis of the lake Superior iron ores. (Econ. Geol., vol. 1, pp. 47-66, Oct.-Nov., 1905.)

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Ore deposition and deep mining. (Econ. Geol., vol. 1, pp. 34-46, Oct.-Nov., 1905.)

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Secondary enrichment of veins. (Eng. Min. Jour., vol. 80, p. 788, Oct. 28, 1905.)

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Geology of the Central Copper River region, Alaska. U. S. Geol. Sur., Prof. Pap. 41, pp. 133, pls. 20, maps, 1905.

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A new sabre tooth from California. (Bull. Dept. Geol., Univ. Cal., vol. 4, pp. 171-175, July, 1905.)

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Crystallization of luzonite; and other crystallographic studies. (Am. Jour. Sci., vol. 22, pp. 277-284, Oct., 1905.)

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Water supplies at Waterloo, Iowa. (Wat. Sup. Ir. Pap., 145, pp. 148-155, 1905.)

PURDUE, A. H.

Water resources of the Winslow quadrangle, Arkansas. (Wat. Sup. Ir. Pap., 145, 84-87, 1905.)

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Water resources of the contact region between the Paleozoic and Mississippi embayment deposits in northern Arkansas. (Wat. Sup. Ir. Pap., 145, pp. 88-119, 1905.)

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RANSOME, F. L.

The present standing of applied geology. (Econ. Geol., vol. 1, pp. 1-10, Oct.-Nov., 1905.)

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Preliminary note on some overthrust faults in central New York. (Am. Jour. Sci., vol. 22, pp. 308-311, October, 1905.)

SINCLAIR, W. J.

New mammalia from the Quaternary caves of California. (Bull. Geol., Univ. Cal., vol. 4, pp. 145-161, pls. 19-23, July, 1905.)

SMITH, GEO. O.

Water supply from Glacial gravels near Augusta, Maine. (Wat. Sup. Ir. Pap., 145, pp. 156-160, 1905.)

SMITH, GEO. O.

Water resources of the Portsmouth-York region, New Hampshire and Maine. (Wat. Sup. Ir. Pap., 145, pp. 120-128, 1905.)

SMITH, W. S. TANGIER.

Water resources of the Joplin district, Missouri-Kansas. (Wat. Sup. Ir. Pap., 145, pp. 74-83, 1905.)

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Geology of the Tonopah mining district, Nevada. U. S. Geol. Sur., Prof. Pap. 42, pp. 295, pls. 24, 1905.

STOSE, G. W. (and G. C. MARTIN).

Water resources of the Pawpaw and Hancock quadrangle, West Virginia, Maryland and Pennsylvania. (Wat. Sup. Ir. Pap., 145, pp. 58-63, 1905.)

SULLIVAN, E. C.

The chemistry of ore-deposition; precipitation of copper by natural silicates. (Econ. Geol., vol. 1, pp. 67-73, Oct.-Nov., 1905.)

TAYLOR, THOMAS U.

The water powers of Texas. Wat. Sup. Ir. Pap., 105, pp. 116, pls. 17, 1905.

ULRICH, E. O. (See BAIN, H. F.)

WEED, W. H.

Notes on certain hot springs of the southern United States. (Wat. Sup. Ir. Pap., 145, pp. 185-206, 1905.)

WRIGHT, F. E.

Determining of the optical character of birefracting minerals. (Am. Jour. Sci., vol. 22, pp. 285-296, October, 1905.)

CORRESPONDENCE

TWO CARBONIFEROUS GENERA.—I notice that two generic names appear to be in use for Carboniferous fossils (c f. Weller, Bibl. Index. N. Am. Carb. Invert.) are homonyms, and untenable.

(1) *Microdon*, Conrad, 1842 (Mollusca); not *Microdon*, Meigen, 1803. The name *Cypricardella*, Hall, is available. The species (following Weller) will stand as *Cypricardella bellistriata* (Conrad), *C. connata* (Walcott), *C. elliptica* (Whitfield), *C. eximia* Miller & Gurley *C. gorbyi* Miller, *C. nucleata* Hall, *C. oblonga* Hall, *C quadrata* White & Whitfield *C. reservata* (Hall), *C subelliptica* Hall.

(2) *Prestwichia*, Woodward, 1867 (Crustacea); not *Prestwichia*, Lubbock, 1863. The name *Euproops*, Meek, is available for this genus. The species are *E. colletti* White, *E. danae* (M. & W.), and *E. longispina* Packard.

Goniodon, Herrick, 1888 (Mollusca), would be rejected by those who rejected *Calamodon* because of *Calamodus* (of Palmer, Index Generum mammalium, p. 151), as *Goniodus*, in fishes, is of course much earlier. This, however, is an extreme view, hardly likely to prevail. In the *Index zoologicus* Herrick's *Goniodon* is omitted, but there is cited a *Goniodon*, Perrier, in Echinoderms, without date. (c f. also Gregory, in Bather, Treatise on Zoology, part iii, p. 253.)

T. D. A. COCKERELL.

University of Colorado, Boulder, Colo.

PERSONAL AND SCIENTIFIC NEWS.

MR. EDWARD H. BERRY, paleobotanist and secretary of the Torrey Botanical Club, is engaged in studying the fossil flora of Maryland for the Geological Survey of that state. His address is "Geological Survey, Johns Hopkins University, Baltimore, Md."

DR. W. B. DAWSON, brother of the late Dr. Geo. M. Dawson, is making a tidal survey of the Pacific coast of Canada.

DR. ROBERT BELL, is making a trip via Skagway to Dawson, in Yukon territory.

DR JOSEPH HYDE PRATT, of the North Carolina Geological Survey, is on an extended trip in Arizona and Montana, examining mining properties.

AT HARVARD UNIVERSITY Messrs. R. Kent and H. N. Eaton have been appointed assistants in geology.

THE NEXT MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCMENT OF SCIENCE will be held at New Orleans. It has been ascertained by the permanent secretary that by Dec. 29, in the judgment of public health and hospital officials, all danger from yellow fever will have disappeared.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY—It has been decided by the corporation of the Institute that the plans entertained for some time past for the consolidation, or "cooperation" of the Institute with Harvard University, have to be abandoned, owing to the late decision of the supreme court relative to the land on Boylston street. In a circular lately issued by Pres. H. S. Pritchett the friends of the Institute are invited to hearty cooperation in its future upbuilding.

DR. H. W. FAIRBANKS of Berkeley, California, recently made a horseback trip with his wife and little daughter, from the Dalles in Oregon to San Francisco, passing over the highest ranges of the Sierra mountains, incurring many of the hardships and perils of camp life. It was for photographing the topographic and geologic features preparatory to a new work on which he is engaged.

WEIGHT OF BRONTOSAURUS. From measurements and estimates made at Columbia University by Prof. William Hallock and W. K. Gregory, upon a restoration of Brontosaurus excelsus made by Charles R. Knight, the saurian was found to have had a weight of about 38 tons. The mounted skeleton, at the American Museum of Natural History, is 66 feet 7 inches long.

DR. C. R. J. LAFLAME, president of the Royal Society of Canada has been appointed by the international water-

ways commission to make a report upon the recession of the Canadian side of Niagara falls.

"ECONOMIC GEOLOGY" is a new semi-quarterly journal devoted to geology as applied to mining and allied industries, the editor of which is Prof. John Duer Irving, Lehigh University, South Bethlehem, Pa. Its first number is dated October-November, 1905. It is an octavo of 100 pages. Associate editors are Waldemar Lindgren, James Furman Kemp, Frederick Leslie Ransome, Heinrich Ries, Marius R. Campbell and Charles Kenneth Leith.

A MEETING OF THE MEMBERS OF THE DIVISION OF HYDROLOGY of the United States Geological Survey who are engaged in the artesian water and related geologic investigations was held in Washington Saturday, December 9th, for the purpose of organizing a society for the discussion of problems relating to underground waters and methods of increasing the efficiency and economic value of investigations. Among those attending the meeting were F. H. Newell, Chief Engineer of the Geological Survey, and officials and members of the division of hydrology. The formation of the new society was decided upon, but the details of organization were left to a future meeting.

THE HAYDEN MEMORIAL GOLD MEDAL was awarded November 7 by the Academy of Natural Sciences of Philadelphia to Dr. C. D. Walcott Director of the United States Geological Survey.

DR. C. H. GORDON, lately of the New Mexico School of Mines, is occupied in the study of the geology and the ore deposits of certain districts in New Mexico for the United States Geological Survey.

THE EIGHTEENTH WINTER MEETING of the Geological Society of America will be held at Ottawa, Can., Dec. 27-29, 1905. The President is professor R. Pumpolly.

ERRATA FOR VOLUME XXXV.

The plate facing page 104 should be numbered x. Page 245, line 5 from the bottom, for "inspection" read instruction. Page 404, line 4 from the bottom, for xxxiv read xxxv. Page 285, line 18, for "they" read three.

ERRATA FOR VOLUME XXXVI.

Page 187, line 62 for "W. U." read G. F. M. Page 250, in the "Editorial Comment" all references to the plate should read plate xiii instead of "plate xvi," and the title should read Willamette instead of "Williamette."

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Index for Volumes I-XXXVI.

EXPLANATION. There are general heads under grouped, viz: Cretaceous, bibliography, geology, etc. minerals are divided into two groups, viz: those refe species, generally "reviewed", and those relating to aspects. In the former group the authors' names are latter they are. "Fossils" are also divided into two tological papers "reviewed", and papers consisting tions of species.

In all cases the arrangement of titles under the under the groups, is chronological and not alphabe.

The index is not an alphabetical one, with ma but, under a general alphabetical regimen it is geo ological. Subjects relating to each state are grou of the state: but all the Canadian states, includin listed under the head of "Canada".

ABBREVIATIONS. (abs) = abstract; (Am. American committee at the International Cong the London session, 1888; (cit.) cited; (rev.) mark; (p. s. n.) personal or scientific note; (ment, (obit.) obituary notice.

B

C

E

F

Fossils, New Descriptions.

G

H

Index, Volumes I-XXXVI.

This two-page list should be inserted on page 56 between GOODWIN and GUANO

I

K

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